

PIERRE GASSENDI'S PHILOSOPHY AND SCIENCE

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PIERRE GASSENDI'S  
PHILOSOPHY AND SCIENCE

*Atomism for Empiricists*

BY

SAUL FISHER



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*On the cover:* Portrait of Pierre Gassendi, from Charles Perrault, *Les Hommes illustres qui ont paru en France pendant ce siècle: avec leurs portraits au naturel* (Paris: Antoine Dezallier, vol. 1, 1696; vol. 2, 1700). Courtesy of the Smithsonian Institute Libraries.

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## PREFACE

Some years ago a well-known, living philosopher offered me his thoughts regarding the comparative merits of Pierre Gassendi and another well-known, deceased philosopher, who shall also go unnamed but is generally acknowledged to have some debts to Gassendi. The well-known philosopher of the past fared surprisingly poorly in this assessment, his lesser known predecessor fared surprisingly well. “Gassendi—he’s a terrific philosopher!” said our contemporary critic, a worthy historian of philosophy. Such an upbeat assessment may be a diminishing mystery these days, following a resurgence of interest in minor seventeenth century figures and a wave of exegetical work focusing on the Descartes-Gassendi debate. Nonetheless, it remains a major undertaking for any student of the early modern period to get a very good idea of Gassendi’s philosophical and scientific projects and their intricacies and relations. The primary effect of the contemporary critic’s remark was to challenge any vestige in my thinking of the notion that Gassendi is lesser-known—and his works hard to know—because he is a deserved lesser light. Indeed, against the background of hundreds of years of Gassendi belittling,<sup>1</sup> I conceive of my challenge as presenting his thought, or some core elements thereof, in a light that illuminates his deserved significance.

My focus is the epistemological and scientific element of Gassendi’s thought, and in particular the relations between his empiricism and atomism. The pressing question for any adherent of those two views is how they might possibly fit together, and my short, judgmental

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<sup>1</sup> In the history of ideas, critics can be merciless to the perceived ‘loser’ of grand debates. Thus, for example, Voltaire offers ridicule: “Dieu me préserve d’employer 300 pages à l’histoire de Gassendi! La vie est trop courte, le temps trop précieux, pour dire des choses inutiles.” (to the Abbé Dubos at Cirey, October 30, 1738.) And in more recent times, Koyré renders this damning judgment: “En effet Gassendi n’est pas un grand savant, et dans l’histoire de la science, au sens strict du terme, la place qui lui revient n’est pas très importante.” Q.v. Koyré, “Gassendi et la science de son temps.” In Comité du Tricentenaire de Gassendi (ed.), *Actes du Congrès du Tricentenaire de Pierre Gassendi (1655–1955)* (Paris: Presses Universitaires de France, 1957), 175.

answer relative to Gassendi is that in the end they cannot, at least with any pretensions to success. My long answer—premised on pursuit of the history of philosophy with a principle of charity firmly in place—takes us through his strongly Epicurean theory of empirical knowledge, the scientific methodological principles he crafts (in part) after his rich experimental and observational work, and his extensive explorations of a physical atomism borrowed as a working hypothesis from ancient traditions. My long answer represents Gassendi as a philosopher who, despite his many historical debts, fashions an innovative empiricist method that is supposed to accommodate warranted claims about the hidden by reference to more traditional empirical warrant for associated claims about the evident. He builds the latter sort of warrant on claims concerning the nature and operations of our perceptual *apparati*—hence on his atomist views of sense perception. This is at once broadly inventive yet corrosive relative to his own specific project. His views are remarkable, their flaws notwithstanding, for providing a robust empiricism that pays homage to and renders profound analysis of past thought, builds on carefully outlined reasoning, and incorporates the lessons of scientific practice as pursued by himself and his contemporaries.

My own debts in telling this story—historical and otherwise—are many and extend back quite some years. Some of those to whom I owe great thanks include Antonio Clericuzio, Dennis Des Chene, Karen Detlefsen, Lisa Downing, Jonathan Kastin, Arnold Koslow, Mark Kulstad, Charles Landesman, Aaron Lipeles, Christoph Lüthy, Emily Michael, Fred Michael, Sylvia Murr, Carla Rita Palmerino, Sophie Roux, Lisa Shapiro, and Martin Tamny. These (and other) patient souls threw caution to the wind in believing that they might learn about Gassendi from my meager efforts—and at primeval stages in the evolution of my thinking, no less. Yet in so doing they encouraged me to be that much bolder in my analysis, thereby increasing risk of error. This is the truth worth noting that underlies the stock acknowledgement that all faults are strictly my own.

Much of the material for this study led a former life as my doctoral dissertation in Philosophy at the CUNY Graduate Center—and some years on, while the manuscript is clearly the better it is hard to see how one might improve on the education I received at the Graduate Center. Diverse experience helps, though, and one such source of advancement was a fruitful year at the *Laboratoire de l'Histoire des Sciences et Techniques* of the CNRS (1994–1995).



Further diversity, encouragement, and development was provided by my HOPOS confrères (as Working Group and later, International Society) in the history of philosophy of science, through the electronic mailing list and conferences (Roanoke, Virginia, 1996; University of Notre Dame, 1998; Montréal, 2002; San Francisco, 2004). The variety among my intellectual fora radically increased in my recent years at the Andrew W. Mellon Foundation, where my philosophical disposition was cheerily entertained and, once in a while, found entertaining. I offer thanks to my Mellon friends for their inspiration, advice, and assistance.

I am also thankful for assistance provided by the Institute of International Education (Fulbright grant for research in France, 1994–1995), the Foundation for Intellectual History (for participation in the 1996 St Andrews Workshop on Late Medieval and Early Modern Matter Theory), and the Graduate School and University Center of The City University of New York (Dissertation Year Fellowship, 1995–1996). I offer gratitude as well to the staffs of these libraries and archives: the Manuscripts Division of the Bibliothèque nationale de France, the Bibliothèque Mazarine, the Bibliothèque Sainte-Geneviève, the Archives du Collège de France, the Bibliothèque Inguimbertaine (Carpentras), the New York Public Library, and the Mina Rees CUNY Graduate Center Library.

I thank as well my family, Mayrav, Yael, and Noa—three especially curious and challenging minds.



## NOTICE TO THE READER

Gassendi's works are cited according to the standard edition of the *Opera Omnia* (Lyons: Laurent Anisson and Jean Baptiste Devenet, 1658; reproduction, Stuttgart-Bad Cannstatt: Friedrich Frommann Verlag, 1964). The *Opera Omnia* are cited as *O*, followed by the volume number in Roman numerals, the page number in Arabic numerals, and the folio side given as *a* or *b* (where applicable). Citations of volumes I and II are by default references to the *Syntagma Philosophicum*, and citations of volume VI are by default references to the Latin correspondence. All other citations identify the relevant essay or correspondence.

Translated versions of cited texts (where available) are listed following citations from the original version.

The following abbreviations are used for original and translated versions of Gassendi's works, and for other commonly referenced pre-modern writings. Complete references appear in the bibliography.

### *Abbreviations*

#### 1. *Manuscripts, Original Editions, Reproductions, and Early Translations*

- MI*     *De Motu Impresso a Motore Translato. Epistolae Duae. In quibus aliquot praecipuae tum de Motu universe, tum speciatim de Motu Terrae attributo difficultates explicantur.* 1642.
- AM*     *De Apparente Magnitudine Solis humilis et sublimis, Epistolae quatuor. In quibus complura Physica, Opticaque Problemata proponuntur et explicantur.* 1642.
- DM*     *Disquisitio Metaphysica seu Dubitationes & Instantiae adversus Renati Cartesii Metaphysicam & Reponsa.* 1644.
- PGDA*     *De proportione, qua gravia decidentia accelerantur epistolae tres: quibus ad totidem epistolas R.P. Petri Cazraei Societatis Iesu respondetur.* 1646.
- AN*     *Animadversiones in decimum librum Diogenis Laertii.* 1649.
- RL*     *Recueil de lettres des sieurs Morin, de la Roche, de Nevre et Gassend,*

*en suite de l'apologie du sieur Gassend touchant la question "de Motu impresso a motore translato". . . . 1650.*

*O Opera Omnia.* 1658.

## 2. Modern Editions and Translations

- EP Exercitationes Paradoxicae Adversus Aristoteles.* (1624). Ed. and trans. Bernard Rochot. Paris: J. Vrin, 1959.
- R Disquisitio Metaphysica seu Dubitationes & Instantiae adversus Renati Cartesii Metaphysicam & Reponsa.* (1644). Ed. and trans. Bernard Rochot. Paris: J. Vrin, 1964.
- IL Institutio Logica.* (1658). Ed. and trans. Howard Jones. Assen, The Netherlands: Van Gorcum, 1981.
- B Selected Works.* Trans. Craig Brush. New York: Johnson Reprints, 1972.
- VP Viri illustris Nicolai Claudii Fabricii de Peiresc, senatoris Aquisextiensis, uita.* (1641). Trans. Roger Lasalle, with Agnes Bresson, pref. Jean Emelina. Paris: Belin, 1992.
- SPE Syntagma Philosophiae Epicuri.* (1649). Trans. Paul Westholm Johnson. Ph.D. Diss., University of Cincinnati, 1993.
- VT Vita Tychonis Brahei, Copernici, Peurbachij & Regiomontani.* (1654/1658). Trans. Jean Peyroux. Paris: A. Blanchard, 1996.
- IA Institutio Astronomica cum Oratione Inaugurali.* (1645/1658). Trans. Jean Peyroux. Paris: A. Blanchard (distribution), 1997.
- T Opera Omnia, Book VI (Latin correspondence).* Trans. Sylvie Taussig. Turnhout: Brepols, 2004.

A handful of classical and early modern writings are also cited by abbreviation:

- De Gen* Aristotle, *De Generatione et Corruptione.*
- PA* Aristotle, *Posterior Analytics.*
- NO* Bacon, Francis, *Novum Organum.*
- Journal* Beeckman, Isaac, *Journal.*
- Bernier* Bernier, François, *Abrégé de la philosophie de Gassendi.*
- AT* Descartes, René, *Œuvres de Descartes.*
- PP* Descartes, René, *Principles of Philosophy.* (Miller & Miller translation).

<i>CSM</i>	Descartes, René, <i>The Philosophical Writings of Descartes</i> . (Cottingham, Stoothoof & Murdoch translation).
<i>DL</i>	Diogenes Laertius, <i>Lives and Opinions of the Eminent Philosophers</i> .
<i>Her</i>	Epicurus, <i>Letter to Herodotus</i> .
<i>Pyth</i>	Epicurus, <i>Letter to Pythocles</i> .
<i>HS</i>	Galen, <i>De Elementis ex Hippocratis Sententia</i> .
<i>EN</i>	Galilei, Galileo, <i>Opere</i> .
<i>RN</i>	Lucretius, Titus Carus, <i>De Rerum Naturae</i> .
<i>MC</i>	Mersenne, Marin, <i>Correspondence du P. Marin Mersenne</i> .
<i>OC</i>	Pascal, Blaise, <i>Œuvres Complètes</i> .
<i>TdL</i>	Peiresc, Nicolas-Claude Fabri de, <i>Lettres de Peiresc</i> .
<i>SE</i>	Sextus Empiricus, <i>Works</i> .
<i>PH</i>	Sextus Empiricus, <i>Pyrroneioi Hypotyposesis</i> ( <i>Outlines of Pyrrhonism</i> ).
<i>Adv. Math.</i>	Sextus Empiricus, <i>Adversus Mathematicos</i> ( <i>Against the Grammarians</i> ).

Other works of Gassendi—original editions and translations—were consulted though referred to in this study minimally if at all; for the reader’s reference, these are included in the bibliography. An excellent, if outdated, bibliography of Gassendi’s writings and secondary sources is Bloch and Lennon (1993).

The spelling and sentence structure but not the antique lettering of Latin quotations has been retained—thus ‘*f*’ is rendered as ‘s’ and ‘v’ as ‘u’. The spelling and diacritics (or the lack thereof) of early modern French quotations has been retained—thus ‘*même*’ appears as it is typically rendered, ‘*mesme*’.

An earlier version of elements of chapters 7 and 8 appeared in Fisher (2000); elements of the Introduction and Foreword appeared in Fisher (2005); and of chapter 4 appeared in Fisher (1998); and portions of chapter 11 appeared in Fisher (2003) and of chapter 5 in Fisher (2004).



## FOREWORD

### *A New, Integrated Picture of Gassendi*

The precise place of Pierre Gassendi in the history of early modern philosophy and science is rather neglected by recent Gassendi scholarship, because of that difficulty which afflicts the blind man relative to the elephant; we get starkly different and exaggerated notions of the creature from the perception of his vastly different parts, and so miss his character as seen in its entirety. Seen only from one aspect or another, it is not even a fair task to locate his exact and full historical significance. The situation is all the worse as a contextualist tradition has tended to portray Gassendi as an opponent of one or another contemporary, to the neglect of his positive theses. The laudable goal of such contextualist studies is to demonstrate his key role in numerous important debates of the early modern era, yet the picture that emerges from some deliberation on these commentaries is rather Gassendi's relative eclipse by other figures, notably Descartes. For example, one historical approach highlights a strong anti-Aristotelian strain which guides Gassendi's earlier criticisms of the scholastics as well as his later Epicurean works.<sup>1</sup> A consequence of this view is that in effect Gassendi may be seen as fighting some of the same battles as Descartes. Gassendi inevitably loses in any such comparison because he engages his foes with generally lesser flash and apparently less sophisticated, or at least less novel, weaponry. Another common approach is to emphasize historicist and rhetorical elements of Gassendi's method, as employed in his conversations and correspondence with members of the Mersenne circle.<sup>2</sup> Gassendi's

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<sup>1</sup> Q.v. Barry Brundell, *Pierre Gassendi: From Aristotelianism to a New Natural Philosophy* (Dordrecht; Boston: D. Reidel, 1987).

<sup>2</sup> Q.v. Lynn S. Joy, *Gassendi the Atomist* (Cambridge: Cambridge University Press, 1987), Jean-Charles Darmon, *Philosophie Épicurienne et Littérature au XVII<sup>e</sup> Siècle en France: Études sur Gassendi, Cyrano de Bergerac, La Fontaine, Saint-Evremond* (Paris: Presses Universitaires de France, 1998), Simone Mazauric, *Gassendi, Pascal, et la Querelle du Vide* (Paris: Presses Universitaires de France, 1998), Sylvie Taussig, "Introduction", in *Pierre Gassendi: Vie et Mœurs d'Épicure*, trans., intro., annot., Sylvie Taussig (Paris: Éditions Alive, 2001), 11–90, and Sylvie Taussig, *Pierre Gassendi (1592–1655): Introduction à la Vie Savante* (Turnhout: Brepols, 2003).

role in this circle was by no means marginal, and it is impossible to downplay the centrality of that circle in early modern scientific debate. It is important to remember, though, that the most important figure to this group was not actually an active participant in it, and this was Descartes. Mersenne, of course, is the other core personality in this context, and so Gassendi by default is at best a third.<sup>3</sup>

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Taussig and Darmon place an even greater emphasis on Gassendi's membership in another discussion group, the *libertins érudits*. Other members of this diverse group, on a broad construal, included Guy Patin, Pierre Charron, François Le Vayer La Mothe, Gabriel Naudé, Théophile de Viau, and Cyrano de Bergerac. Molière is also sometimes considered to have belonged to the *libertins*, and he is thought to have studied under Gassendi's informal tutelage (q.v. Gaston Sortais, *La Philosophie Moderne depuis Bacon jusqu'à Leibniz* (Paris: Paul Lethielleux, 1922), volume two, 228–232). Gassendi's ties to the *libertins* also brought him in contact with a range of other intellectuals and artists—the latter including, most notably, Nicolas Poussin (q.v. *Colloque Nicolas Poussin. Paris, 19–21 septembre, 1958*, ed. André Chastel (Paris: Centre National de la Recherche Scientifique, 1960)). (The extensive literature on the *libertins* also includes Françoise Charles-Daubert, *Les Libertins Érudits en France au XVII<sup>e</sup> Siècle* (Paris: Presses Universitaires de France, 1998), Antoine Adam, *Les Libertins du XVII<sup>e</sup> Siècle* (Paris: Buchet-Chastel, 1986), René Pintard, *Le Libertinage Érudit dans la Première Moitié du XVII<sup>e</sup> Siècle* (Paris: Boivin, 1943; Reprint edition, Geneva and Paris: Slatkine, 1983), and J.S. Spink, *French Free-Thought from Gassendi to Voltaire* (London: The Athlone Press of the University of London, 1960)). The *libertins*, constituting more of a literary salon than the philosophically- and scientifically-oriented Mersenne circle, promoted a morality stripped of theological considerations and defined on an individualist basis. In their commitment to intellectual liberty, they professed a diverse mix of metaphysical and epistemic views, especially materialism, skepticism, rationalism, deism, and Epicureanism—each party to the group offering a different mix. They were politically and socially savvy enough to promote their libertine views in a manner and style that verges on the secretive. Such secrecy as a guiding stylistic force can be seen in aspects of Gassendi's writing and rhetorical style, as he frequently makes allusions likely to be understood only by his friends or the equally erudite, constantly draws on expressions from ancient sources to make his own points, and offers a variety of quasi-coded rhetorical elements, most notably his hesitating and greatly qualified endorsement of the Copernican model.

Owing to their largely individualist conception of ethics, the *libertins* tended to avoid political theory and larger social issues, focusing instead on self-governance and morality understood in terms of character—in keeping as well with late Renaissance tradition. Gassendi generally follows this conception in his ethics (q.v. Lisa T. Sarasohn, *Gassendi's Ethics* (Ithaca and London: Cornell University Press, 1996)), though he also outlines a broader political theory (q.v. Gianni Paganini, “Epicurisme et philosophie au XVII<sup>e</sup> Siècle, Convention, Utilité et Droit selon Gassendi”, *Studi Filosofici* 12–13 (1989–1990), 5–45). Aside from these elements of his ethics and rhetoric or style, it is an open question as to how much effect Gassendi's association with the *libertins* had on his views. It is an equally significant question as to how much influence Gassendi's rhetorical method may have had on the *libertins*.

<sup>3</sup> It is far from clear, in any case, that other members of Mersenne's circle found the historicizing aspect of Gassendi's writings to be the most compelling aspect of his work.



There is no better place to see Gassendi poorly comparing with Descartes, however, than in the recent literature on their direct conflict over the *Meditations*. Here the focus is on Gassendi's role as the premier contemporary critic of Descartes, and his anti-cartesian views are presented as a prism through which we may best perceive the spectrum of his views.<sup>4</sup> While there is undoubtedly a good case to be made for the claim that he represents the most prominent alternative to Descartes in his times, putting a spotlight on this facet of Gassendi's career encourages the view that he deserves no more than footnote status and emphasizes, at least historically speaking, his role as the *losing* alternative. Indeed, as I suggest below, there is manifestly a great deal more to be said about Gassendi than what he believes to be wrong about the *cogito*. It is some indication of the work that remains to be done on comprehending Gassendi's thought that, by comparison, nobody could possibly make a similarly mistaken judgment about Descartes.

An even less promising fashion in the literature has it that Gassendi's doctrinal beliefs form the systematic foundation of, or otherwise greatly influence, his philosophical and scientific views. One such perspective suggests that Gassendi's spiritual concerns and materialist ontology jointly shape the character of his metaphysics—leading to irresolvable internal conflict. Another perspective is that it is primarily his theological views, and specifically his voluntarism, which lead him to his empiricism.<sup>5</sup> Each of these perspectives suggest Gassendi is best understood as laboring in service of a doctrinal credo—or at least as motivating his philosophical views by appeal

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<sup>4</sup> Q.v. Margaret J. Osler, *Divine Will and the Mechanical Philosophy* (Cambridge and New York: Cambridge University Press, 1994), Thomas M. Lennon, *The Battle of the Gods and Giants: The Legacies of Descartes and Gassendi, 1655–1715* (Princeton: Princeton University Press, 1993), and Roger Ariew & Marjorie Grene (eds.) *Descartes and His Contemporaries: Meditations, Objections, and Replies* (Chicago: University of Chicago Press, 1995).

<sup>5</sup> For the first perspective, q.v. Olivier René Bloch, *La Philosophie de Gassendi: Nominalisme, Matérialisme, et Métaphysique* (The Hague: Martinus Nijhoff, 1971) and Sortais (1922); for the second view, q.v. Osler (1994) and Sarasohn (1996). Sylvia Murr offers a *via media*, proposing that the relationship between Gassendi's theology and philosophy illuminates a core role of religiosity in his thought—but only as one influence along with that of the classical authors, the Church fathers, his contemporary correspondents, and his own experiments and astronomical observations; q.v. Murr, "Gassendi's Scepticism as a Religious Attitude", in *Scepticism and Irreligion in the Seventeenth and Eighteenth Centuries*, ed. Richard H. Popkin & Arjo Vanderjagt (Leiden: Brill, 1993), 12–30.

to his theological sensibility. Such a suggestion is off the mark. He indeed tailors his Epicurean views to meet theological constraints and endorses the only astronomical world-view he believes acceptable to the Church, that of Tycho Brahe. Yet Gassendi's definitive criterion for any physical, metaphysical, or epistemological thesis is its approximation to the truth, which he generally views as empirically-determined. It is also the case that some theologically inspired claims are woven deeply into the fabric of his metaphysics and psychology. For example, he holds that there are two souls, one rational and the other not, and he intends the former to satisfy religious demands for an immortal unity attached to, but not susceptible to the fate of, the material body. But in such cases Gassendi is generally clear about his non-philosophical motives in introducing such corrections or additions to his reasoned or empirically demonstrated views as are necessary by the dictates of faith or Scripture.<sup>6</sup> To suggest that he arrives at the core tenets of his metaphysics or epistemology as a means of drawing out the ultimate consequences of his theology thereby misconstrues not only his broad philosophical motives but his particular reflective and investigative strategies as well.

By contrast, another element of recent scholarship highlights Gassendi's philosophical motivations and strategies in *sensu strictu*.<sup>7</sup> In

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<sup>6</sup> Whatever its significance or influence, Gassendi's religiosity does not prevent his philosophical thought from being separated out and identified as such. He frequently defends the primacy of his Catholicism and faith over natural reason (q.v. for example *O I* 5a, *O I* 49a, and *O II* 237a–b). Yet he explores those issues most pertinent to and best illuminated by reason and empirical evidence through the self-same vehicles of reason and the empirical, rather than by reference to faith, doctrine, or history. Moreover, as Tullio Gregory has noted, Gassendi has no difficulty in distinguishing between the objects of scientific and theological investigation and reflection; q.v. Gregory, *Genèse de la Raison Classique de Charron à Descartes*, trans. Marilène Raiola; pref. Jean-Robert Armogathe (Paris: Presses Universitaires de France, 2000). In his May 7, 1645 letter to Père Cazrée, Gassendi writes:

... I was truly astonished that you subsumed under theology and the supernatural those things belonging purely to physics and resulting completely by nature, such that one may no longer distinguish between what occurs by the forces of nature and what actually occurs or may occur by supernatural power (*O III (De Proportione)* 636a).

<sup>7</sup> In the years during and following the Second World War, Bernard Rochot began this trend by bringing to light numerous lesser-known texts as well as the manuscript background to Gassendist atomism. More recently, Fred and Emily Michael have called attention to empiricist sources and features of Gassendi's psychology and epistemology. Others offering assessments of Gassendi's views in similarly strict philosophical terms include Wolfgang Detel, Marco Messeri, and Antonia LoLordo.

this interpretive tradition, Richard Popkin elegantly poses the global character of the empiricism linking Gassendist philosophy and science.<sup>8</sup> Popkin ties together two central facets of Gassendi's thought, proposing that the 'constructive skepticism' at the core of his epistemological views is an attempt (among other things) to show how to have an atomist science—through inferences based on our data concerning appearances:

Gassendi did not claim we could discover the real nature of objects by experiential reasoning. . . . Rather, he claimed that we could find scientific explanations of the causes of our experience . . . [and that such explanations constitute knowledge which] . . . results from a most careful examination of appearances and a most cautious rational evaluation of the data derived from them. This evaluation is not based on knowing the real nature of things, but on a consideration of the conditions that would make our experience both possible and intelligible. For Gassendi, the best explanatory system was atomism, which can account for the sense qualities we experience and can provide a model for the known data about the observable world. Gassendi's atomism, derived from a study of the classical Epicurean texts, was not advanced as a metaphysical theory about the true nature of things. The atomic world is inferred from experiential indicative signs. It is confirmed by verifying predictions about atomic effects in the observable world. Gassendi limited his descriptions of the characteristics of atoms to sensory qualities found in experience.<sup>9</sup>

Thus the starting point of Gassendi's philosophy, in Popkin's view, is skepticism about knowledge of essences, which is mitigated by allowance for warranted beliefs about appearances and causal knowledge to which we are entitled just because it helps us to make sense of beliefs about appearances. There are a few small difficulties here yet, as I argue over the course of this study, Popkin's picture is largely correct. One problem is that Popkin is wrong to suggest that characteristics of atoms simply resemble the features found in experience. As I detail in Part Three, the way atoms move in Gassendi's view is quite distinct from the sensible motion of supra-atomic bodies. Another problem is Popkin's suggestion that Gassendi rules out knowledge of

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<sup>8</sup> Richard Popkin, "Gassendi, Pierre" in *The Encyclopedia of Philosophy*, ed. Paul Edwards (New York: Macmillan and the Free Press, 1967), Volume 3, 269–273; cf. also Popkin, *The History of Scepticism: From Savonarola to Bayle*, Revised and expanded edition (earlier editions, 1960/1979) (Oxford: Oxford University Press, 2003), chapter seven.

<sup>9</sup> Popkin (1967), 271.

essences as the basis for accepting atomism and instead embraces atomism solely on the basis of an empiricist strategy that looks like inference to the best explanation (IBE). As I suggest in Part Three, it is not clear that Gassendi must reject the former even if he accepts the latter, nor is it so that he actually relies on such empiricist argument *alone* to defend atomist claims. Finally, a related apparent problem is that, given that we infer beliefs about atoms from experience and confirm those beliefs on the basis of their predictive value, it seems we land on atomism in virtue of the supporting evidence and not the explanatory value of the thesis; hence there should be a diminished (though not necessarily empty) role for IBE arguments.

Overall, however, Popkin's assessment yields a correct understanding of Gassendi. Further, his assessment hints at an intriguing characterization of IBE that Gassendi appears to promote. Gassendi indeed defends atomism by appealing to its explanatory value—but he cannot grant that the evidence could be equally compelling for all competing theses, because he holds that atomism is the physical thesis which best makes intelligible our experiential data to begin with. The broader methodological suggestion is that, in considering among physical theses, the way we understand and interpret correlative data about appearances may depend on which such thesis we are entertaining.<sup>10</sup> While Popkin does not anticipate this particular interpretation, he clearly identifies a core challenge in binding together some principal themes in Gassendi's corpus: showing how to be an atomist if one is a thoroughgoing empiricist. Naturally, given the brevity of his remarks, Popkin spells out neither how constructive skepticist principles lend support to a scientific method, nor how a theory of what constitutes empirical knowledge or scientific method might license the particular hypothesis of atomism.

In this study I present a fuller picture of Gassendi than that offered by the many commentators who focus on his negative theses, and I explore at length Popkin's suggestion concerning relations between his philosophy and science.<sup>11</sup> In assessing the conceptual geography

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<sup>10</sup> I return to this issue in chapter fourteen.

<sup>11</sup> Other commentators who share this focus include Wolfgang Detel, *Scientia Rerum Natura Occultarum: Methodologische Studien zur Physik Pierre Gassendis* (Berlin; New York: De Gruyter, 1978); Joy (1987); William Makin, "The Philosophy of Pierre Gassendi: Science and Belief in 17th Century Paris and Provence" (Ph.D. diss., Open University, 1986); Marco Messeri, *Causa e Spiegazione: la Fisica di Pierre Gassendi* (Milan: F. Angeli, 1985); Osler (1994); Tullio Gregory, *Scetticismo ed empirismo: Studio su Gassendi* (Bari:

of Gassendi's epistemology, metaphysics, and physics, I argue for several new views of his thinking: that he anticipates crucial elements of contemporary reliabilist theories of warrant, that he adapts the *regressus* method (previously touted by ancient and Renaissance proponents) to suit his probabilism about empirical knowledge, and that aspects of his atomism fit poorly with the mechanical philosophy it is supposed to exemplify. But the main thrust of my attempt to present the philosophical richness of Gassendi's thought is to depict his philosophical and scientific pursuits as part of one and the same project. This contrasts with a traditional view according to which—despite his frequent and impassioned defenses of empiricism—the inspiration, motivation, and demonstrative grounds for his atomism are instead viewed as purely historical. Any such historicist appeals, however, can only represent part of the story, for Gassendi also argues for atomism as a consequence of his empiricism. He thinks the evidence that warrants his microphysical theory is an outgrowth of our best theory of knowledge and sound scientific method. In this way, Gassendi relies on his empiricism and corresponding theory of method to provide the conditions for a scientifically viable atomism.

In arguing for this interpretation of Gassendi's markedly seventeenth century views, I address this still-pertinent question: what can we expect to know about unobservables given the stance that all knowledge is from the senses? The answer Gassendi offers, which may still address this puzzle in its contemporary form, is that we can know about unobservables like atoms just in case our empiricism advances scientific knowledge through hypothetical reasoning and warrants the sorts of inferences about physical phenomena which allow for unseen features of the world—for which the sensible features can provide evidence.

My starting point for exploring the details of this answer is Gassendi's theory of empirical knowledge (Part One). Against the Stoics and Descartes, Gassendi argues that it is not a necessary condition of our knowing some claim that we be certain of it. This move immediately broadens the range of what we can know through the senses, as does his suggestion that we include among such claims to knowledge those assertions about what may be hidden to the senses yet

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Laterza, 1961); and Lillian Unger Pancheri, "The Atomism of Pierre Gassendi: Ontology for the New Physics" (Ph.D. diss., Tulane University, 1972).

legitimately inferred from evidence of the perceptually given. This is his theory of sign-based inference, which suggests such inferences are legitimate just in case they would be agreed to by a great enough number of experts giving testimony—or else would be false only on pain of contradiction.

On the basis of these epistemological views, Gassendi develops elements of a theory of scientific method, which I outline in Part Two. These elements include the plainly-stated proposal that, while we attain and justify our most firmly rooted empirical claims by deduction—the means of inference outlined in his ‘official’ *regressus* method of justification and discovery—those claims are at root probabilistic. Gassendi also offers, in less plainly stated terms, the proposal that we maintain hypotheses as the basis of scientific reasoning so long as there is empirical evidence for them, however broadly construed. Putting these two elements together, we can see a commitment, which holds in at least in some instances of scientific reasoning that Gassendi discusses, to a hypothetico-deductivism. Yet this is not a typical or modern species of H-D method, but a resolutely empiricist version.<sup>12</sup>

As I outline in Part Three, Gassendi draws on these and other elements of a scientific method to propose an atomism as a ‘most likely hypothesis’ supported by evidence from the senses. Of necessity, such evidence is found indirectly, in ‘indicative’ signs—those surface level phenomena for which he takes the existence of atoms to be a *sine qua non* condition. A paramount instance of such evidence in Gassendi’s view is what we may see through the microscope. He argues that the microscopic observations of crystalline formation and dissolution demonstrate the molecular structure of matter. Both the

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<sup>12</sup> Detel views Gassendi’s commitment to a hypothetico-deductivism as evidence that he is not entirely the empiricist others have made him out to be; q.v. Detel, “War Gassendi ein Empirist?”, *Studia Leibnitiana* 6 (1974), 178–221, and “Scepticism and Scientific Method—the Case of Gassendi”, in *Wissensideale und Wissenskulturen in der Frühen Neuzeit / Ideals and Cultures of Knowledge in Early Modern Europe*, ed. Wolfgang Detel & Claus Zittel (Berlin: Akademie Verlag, 2002). Yet Gassendi’s great interest in hypotheses and hypothetical reasoning and promotion of some form of deduction neither rely on nor yield the classical notion. For one, as we will see, his form of deductivism is governed altogether by his empiricist interests. For another, several *other* forms of inference that he endorses or makes use of are fundamental to his scientific method. These include sign-based inference, analogous reasoning, and inference to the best explanation, none of which are deductivist in an orthodox sense, if at all.

molecularist view and this putative source of warrant are key innovations of his atomist programme.

In Part Four, I further explore aspects of Gassendi's appeals to indirect evidence for claims about the unobservable, and his willingness to count such evidence as adequate empirical grounds for maintaining an atomist hypothesis. For one, his arguments for atomism mark yet another element of his proposed method, an important anticipation of the modern notion of inference to the best explanation (IBE) as a means of judging among competing hypotheses. In advancing this strategy, he emphasizes the capacity of a given hypothesis to account for a range of different phenomena as a guide to the degree to which it approximates the truth. For another, his strategy for justifying claims about atoms indicates a thoroughly empiricist approach to warrant for claims regarding the evident and nonevident alike. There is much that is untenable or unlikely about these views in Gassendi's seventeenth century context, and perhaps regardless of that context, as well. Yet it is an indication of the richness of his philosophy that he stands at the dawn of the modern era with at least a set of proposals as to how to resolve one of empiricism's more vexing questions, still facing its proponents today.

### *Methodological Notes*

My exploration of Gassendi's thought assumes the view that the history of philosophy is an ongoing conversation across the generations—what Edwin Curley has called “dialogues with the dead”<sup>13</sup>—and that grasping this history entails exploring the writings of past philosophers at least partly from the perspective of contemporary questions and issues. Curley's recommended method, in short, is using the presently available tools of philosophy in order to best comprehend arguments offered by the conversants of the past.<sup>14</sup> In fairness, the

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<sup>13</sup> “Dialogues with the Dead”, *Synthese* 67 (1986) 1, 33–49.

<sup>14</sup> Curley's method may appear open to the charges of anachronism and—insofar as such ‘dialogues’ assume the strengths of contemporary perspectives—whiggism. Neither charge is fair, though, if the primary *philosophical* concern is how to best understand arguments in historical texts in light of subsequent developments and contemporary views. Allen Wood proposes that those who work to understand historical philosophical texts through contemporary ‘norms’ or conceptual interpretative frameworks (in the manner Curley suggests) can adopt guidelines to avoid

competing view that the context of philosophers' times is an invaluable guide to their views bears serious and special consideration in the case of Gassendi. Much of his outlook is shaped in response to a variety of discussions local to the early modern period, and I explore such *responsa* where it is crucial for following the train of his thinking.

Moreover, Gassendi's Renaissance manners of scholarship lend his work an expository style that involves review of, and response to, significant portions of the history of science and philosophy. This is so much so that any traditionally contextualist discussion of his work—focusing on his peer-wise interactions or the influence of his immediate predecessors—may miss a broad, if unstated goal of his work. That goal, which we can readily detect from his extensive quotations from and lengthy interpretations of past thinkers, is to address a variety of questions of metaphysics, epistemology, and methodology, against the backdrop of the grand sweep of Western thought. To fairly identify and explain Gassendi's own perspectives, then, I offer a 'grand sweep' analysis, a view of his thinking at least partly abstracted away from the thinking of his contemporary fellow intellectual travelers, and broadened to take account of his treatment of ancient and medieval writers with whom he took himself to be 'conversing'.

Such an expansive historical focus—on what given philosophers see as their contributions to the tradition—respects the greater historical intentions they may have. This is a crucial step in recounting their piece of philosophical history.<sup>15</sup> As Lynn Joy and others have emphasized, such intentions are rather close to the surface for

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confounding past and present thought or making demands on historical texts that they cannot meet; q.v. "What Dead Philosophers Mean", in *Kant verstehen / Understanding Kant: Kant-Interpretationen Analysen—Probleme—Kritik*, ed. Dieter Schönecker & Thomas Zwenger (Würzburg: Königshausen & Neumann, 2000), 272–301. In this study, I have followed Wood's proposal and taken care that a focus on argument that is weakly-contextualist and occasionally present-minded does not neglect the core views, critical background, or maturation of Gassendi's thought.

<sup>15</sup> Philosophers sometimes stake the compelling nature of their arguments on strictly contextual factors such as their persuasiveness measured against competing views—and such rhetorical elements as style, metaphor, or even one's vision of philosophy as an intellectual enterprise. In those instances, historians have a special obligation to provide the context in which arguments are presented, to communicate that their intelligibility and persuasiveness rests on the relevant contrast class of arguments in the background philosophical context. Thanks to Alan Richardson for this point.



Gassendi, who expends much effort discussing the history of philosophical issues. This focus also helps avoid the ‘strong’ contextualist’s error of merely pushing back a presentist framework some hundreds of years. The precise place of a writer’s reasoning in the immense spectrum of Western philosophical history is sometimes located only by grasping such reasoning against the backdrop of that ‘super-context’. Without the benefit of this expansive focus, the strong but temporally-local contextualist approach is well suited to the creation of conceptual maps of broad intellectual connections marking distinctive historical moments. That project—most useful in the history of ideas—is aimed at an understanding that is primarily historical, rather than one that is primarily philosophical.

*An internalist history of philosophy and science*

Beyond the local and super-contexts of Gassendi’s work, I offer a fine-grained analysis of the internal structure and relations of his argumentation. I propose this analysis as a primary contribution of this study; a contingent feature of the current literature is that Gassendi’s philosophy and science are little discussed from a more argument-focused and less contextualist approach. As I have noted, many or even most of Gassendi’s arguments are externally directed: he is so thoroughly engaged with his predecessors and peers in philosophical, scientific, and theological pursuits that understanding his reasoning is inescapably tied to understanding a wide range of ancient, medieval, and early modern thinkers. Accordingly, many commentators have analyzed Gassendi’s work primarily in historical or contemporary context. My aim instead is to burrow into the fertile ground of his argumentation, to ‘reconstruct’ his reasoning and best understand what marks it as his own—influenced by or contrasting with others’ reasoning though it is.

Histories of philosophy and science from such argument-focused perspectives—in the manner of ‘rational reconstruction’—sometimes neglect the background and breeding ground of such argumentation. The methodologies are not mutually exclusive. However, of necessity, historical exercises in each vein have their particular emphases. I appeal to rational reconstruction in order to help clarify Gassendi’s exposition, articulate relations across his perspectives and their constituent arguments, and identify the profundity, lasting value, and even contemporary relevance of his ideas.

It is particularly critical to grasp the underlying structure and network of connections tying together elements of Gassendi's reasoning; few historians or philosophers have attended to this task in any thorough fashion.<sup>16</sup> A dearth of historical work of this stripe is unfortunate in that his writings are frequently burdened by an overly generous supply of historical references and interpretations, woven throughout the text, such that finding his own arguments can present a challenge to the reader. In some instances, this likely amounts to what Joy and others have characterized as 'historical argument'—the rhetorical strategy of evoking and championing the views of historical figures which are close to the views that one wants to defend. Such a strategy is certainly characteristic of large elements of Gassendi's writing, particularly in his correspondence and works dedicated to defense of Epicurus.<sup>17</sup> This facet of Gassendi's thought constitutes a critical element of the way he conceived of his own project but sheds less light on—and may even obfuscate—the reasoning he presents as truly his own. Gassendi directly engages a number of living authors—notably, Descartes, Fludd, Cherbury, and Morin—and his own thinking in those works is manifest. In other, significant works such as the *Syntagma Philosophicum*, his views and those of his key ancient sources—most prominently, Epicurus, Lucretius, Sextus Empiricus, and the Stoics—are often difficult to separate, even to the point where views identified as straightforwardly Epicurean actually reflect Gassendi's own reinterpretations.<sup>18</sup>

Disentangling these strands, and laying bare the Gassendist element, is a crucial first step towards grasping the logical structure of

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<sup>16</sup> Fortunately, this situation has been improving in recent times; careful analyses are offered by Detel, Michael and Michael, Walker, Bloch, Joy, and LoLordo, among others.

<sup>17</sup> Indeed, several studies have carefully drawn attention to how, when, and where Gassendi echoes Epicurean thought; q.v. Bernard Rochot, *Les Travaux de Gassendi sur Epicure et sur l'Atomisme, 1619–1658* (Paris: J. Vrin, 1944); Howard Jones, *Pierre Gassendi, 1592–1655: An Intellectual Biography* (Nieuwkoop: De Graaf, 1981); Antonina M. Alberti, *Sensazione e Realta: Epicuro e Gassendi* (Florence: Leo S. Olschki, 1988); Howard Jones, *The Epicurean Tradition* (London; New York: Routledge, 1989); and Taussig (2001). The challenging task remains to identify why, given any particular issue in question, Gassendi lands on a corresponding Epicurean view as the best way of addressing that issue. This problem is especially pronounced in those of his works which, whether in part or as their main theme, promote Epicurean perspectives—including *De Vita et Moribus Epicuri* (1647), the *Animadversiones in Decimum Librum Diogenis Laertii* (1649), its appended *Philosophiae Epicuri Syntagma* (1649), and even the *Syntagma*.

<sup>18</sup> Q.v. Joy (1987).

his many threads of argument and their relations. Neither this preliminary step nor the larger task of representing the grand logical structure have been at the center of Gassendi scholarship: this study is one attempt to further a historical understanding of his work from these perspectives and to help explain why his peers valued his work—which value prompts the alternative contextualist and externalist readings.

*Philosophy of science in historical perspective*

One last methodological note concerns my focus on the philosophy of science, which special field did not exist, of course, as a well-defined sub-discipline in Gassendi's time.<sup>19</sup> Nonetheless, there are many aspects of what we think of now as philosophy of science in his work—as is well-documented relative to the work of other early modern authors, including Galileo, Descartes, and Huygens. One goal of this study is to pull together those aspects in Gassendi's writings and show how together they may constitute a coherent set of claims about the fundamental nature of the scientific endeavor, even though historically speaking no one at the time referred to those claims or discussion of the same as the 'philosophy of science' *per se*. Some of the early modern writers on scientific method—notably Kepler, Bacon, and Boyle—present their views on the subject in free-standing, dedicated treatises. Gassendi's views are less boldly stated. Thus, he explores various topics—the nature of empirical evidence, the character of inference, the role of hypothesis and hypothetical reasoning, and the acceptance and application of scientific theories—yet presents each of these views in the context of some other domain of inquiry, such as his logic, theory of knowledge, or one of his various scientific investigations.<sup>20</sup> These views on the nature of science and its practice appear throughout his *œuvre* and, as elements of a global perspective on science, may be assessed relative to their

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<sup>19</sup> It is often noted that neither did 'philosophy' or 'science' as we conceive of them today exist in the seventeenth century. While this much is accurate, it is abundantly clear that, going back to the ancients, the forms of literature and activities which we now call 'philosophy' and 'science' were sufficiently well-defined, if not always distinguished, that we can easily recognize the relevant strands of each of these intellectual pursuits in early modern times.

<sup>20</sup> Gassendi's views on method largely assume the central claims of his theory of knowledge and accordingly I present his epistemic views first, in Part One.

individual merit but also their coherence in the aggregate. That Gassendi considers these distinctive views to form a coherent whole is made clear by his frequent appeals to such elements across numerous and diverse analyses of observations and experiments.<sup>21</sup>

Such pursuit of coherent theoretical wholes where the texts in question offer only bits and pieces is likely required given a historiography of philosophy of science the focus of which is prior to the nineteenth century creation of the sub-discipline. Moreover, such investigations cannot be restricted to the writings of philosophers, for some of what emerges as significant to latter-day philosophy of science is produced by those who by current lights would be considered scientists rather than philosophers. The overlap from another direction is also noteworthy: the early moderns (and others writing before the self-conscious maturation of philosophy of science) take as central some methodological, ontological, and epistemic issues which, in later debates concerning the fundamental nature of science, lose their currency and impact.<sup>22</sup>

In Gassendi's writings we find each of these scenarios well-represented. Thus, his theory of explanation suggests that a form of IBE yields viable accounts of the non-manifest, in a manner reminiscent of recent views (q.v. chapter thirteen). His theory of hypothesis resonates greatly with other early modern accounts that allow hypotheses as permissible just in case it is possible to advance empirical arguments on their behalf. Further, his theory of causation—with few affinities to more modern views—is firmly cast in its time. That theory distinguishes between ultimate causation as divine, and strictly of theological interest; and proximate causation as a product of material contact, and within the realm of physical science. Lastly, he introduces a notion of goal-directedness in biology that is not 'finalist' in the classic Aristotelian sense. It is not the ends *per se* but 'goals' of a system that drive, for example, change among biological entities and the development of individuals; such goals are constituted as materially-constituted 'information' already contained in developing beings, which view is exemplified by Gassendi's version of preformationism.

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<sup>21</sup> Q.v. chapters five and eleven.

<sup>22</sup> In this sense, the history of philosophy of science differs not at all from the general case of history of philosophy, in which the socially or traditionally vetted designation of a writer as a philosopher is a sufficient but non-necessary condition for consideration of his or her writings from a philosophical perspective.

## INTRODUCTION

### *BASSES-ALPES* PRIEST, PROVENÇAL SCIENTIST, AND PARISIAN PHILOSOPHER

#### 1. *Savant, Scientist, and Priest*

Born in 1592 to an undistinguished family in the Haute-Provence town of Champtercier,<sup>1</sup> Pierre Gassendi<sup>2</sup> was to become the greatest Provençal scholar of his day, a member of the preeminent French intellectual group of his times—the Mersenne circle—and professor of mathematics at the College Royal. His path to these heights began when his instructors recognized great potential early on, and sent at age sixteen to Aix-en-Provence for studies of further sophistication than his local schooling could provide. In these first years of scholarly pursuit, Gassendi shuttled between Aix and Digne (the provincial capital) and so set a life-long pattern of not staying in one place for very long. His extensive and early education enabled him to win appointment as Professor at Aix while still in his mid-twenties. He was shuttling between careers as well, attaining success and station not only in academic circles but in the Catholic Church as well.

Gassendi's career as a priest is a crucial facet of his intellectual constitution: his writings reflect an unbending allegiance to Holy Scripture and Church teachings, though not necessarily in orthodox doctrinal lights. He was ordained at the age of 24 or 25 and, while

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<sup>1</sup> One person's Haute-Provence is another's Basses-Alpes, depending on temperament and temporal index. Champtercier *is* distinguished by its beauty and charm if not by history.

<sup>2</sup> An entirely inconsequential controversy rages over whether his name is properly 'Gassendi' or 'Gassend'. The answer, if possible, is *both*. The usual account is that his family name is 'Gassend'—and this is how he signs his correspondence—but that he was known widely (in his day, and thereafter) as 'Gassendi' because a contemporary savant incorrectly interpreted his name back from the Latinized 'Gassendus' into French with a supplementary 'i' at the end. It is further possible that, were his family name originally in the Provenço language, it might well have been rendered as 'Gassendi'.

there is no question of the strength of his faith, one motivation for his career in the Church appears to be its provision of a sinecure. Thus Gassendi started at the rank of a low-level local official (Chanoine of the Cathedral) in Digne and rose to the rank of a slightly higher-level local official (Prévôt), still in Digne, some twenty years later.<sup>3</sup> Though he clearly pursued a studied relationship with his higher authority, all the while he wrote letters of support to the Church-embattled Galileo, sought appointment to the secular College Royal, and cultivated deep personal and intellectual ties with his non-Church patrons—the affluent *fonctionnaire*, Francois Luillier; the Provençal savant, Nicole-Pierre Fabri de Peiresc; the local count of Alais, Louis Emmanuel de Valois; and the Parisian noble, Habert de Montmor.

After some years of instructing pupils in philosophy and theology, Gassendi distanced himself from what he believed to be rigid teachings of the Scholastics in his *Exercitationes Paradoxicae* of 1624. Thereafter he began a formative partnership in physiological, astronomical, and historical studies with the wise and wealthy Peiresc, summarized in Gassendi's glowing biography written upon Peiresc's death in 1637. By this time, Gassendi had also developed his early interests in a variety of questions in basic physics and in restoring the philosophy of Epicurus—much as Thomas had restored Aristotle, integrating his thought with what he held to be theologically viable.<sup>4</sup> His writings in philosophical and natural philosophical matters brought him to

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<sup>3</sup> Q.v. Alain Collomp, "Gassendi et la Haute-Provence", in *Peiresc-Gassendi: L'Humanisme Triomphant dans la Provence Baroque*, ed. Mady Smets-Hennekinne (Brussels-Paris-Colmars les Alpes: Édition de la Fondation Nicolas-Claude Fabri de Peiresc, 1992), 89–103.

<sup>4</sup> To put Gassendi's Epicureanism in perspective: he certainly was not the only one since antiquity to defend the philosopher of the garden. Indeed, as Jones (1989) has shown, numerous champions of Epicurus revisited and appropriated his work, from Roman times on. Yet an Epicurean revival in early modern times was still noteworthy against the dominant Aristotelian orientation of the day. As early modern writers struggled to articulate a new vision, the Epicurean framework presented a clear alternative. One contemporary of Gassendi's who also pursued this alternative was Francisco de Quevedo y Villegas (1580–1645). Quevedo defended Epicurus in print roughly at the same time that Gassendi began exploring such a defense in his manuscripts and correspondence; q.v. *Nombre, origen, intento, recomendación y devedencia de la cotrina esotoica. Defiéndose Epicuro de las calumnies vulgares* (1633–1634), in *Obras completas de Quevedo* (Antwerp: for Hendrik and Cornelis Verdussen, 1699; Brussels: François Foppens, 1670), 746 f. (and in a modern edition as *Defensa de Epicuro Contra la Commun Opinion* (Madrid: Editorial Tecnos, S.A., 1986). Gassendi's first published Epicurean work, *De vita*, does not appear until 1647.

the attention of the Minim priest, Marin Mersenne. Gassendi spent the last two decades of his life traveling back and forth between Provence and Paris because of his periodic involvement with the group of philosophers and scientists brought together through correspondence with Mersenne. In the Mersenne circle, debates ranged over numerous topics central to the dismantling of Aristotelian and Scholastic world-views, and Mersenne often used his role as facilitator to bring together opponents on these issues. In that context, Mersenne was instrumental in enabling the entry of Gassendi's criticisms of Descartes's *Meditations* into the *Objections and Replies* (Gassendi subsequently published his rebuttals in his *Disquistio Metaphysica* of 1646). Members of this circle regularly reported on each other's experiments and proposed new challenges, such as Poysson's well-known puzzling over whether physical indivisibles could or should be identified with mathematical points. Gassendi used this forum to learn about other empirical studies as well as to work out a good many of his views.

His scientific career was varied and complex. Some historians consider his greatest accomplishment in this sphere to be his contribution to the revival of ancient atomism (see Part Three) but this represents only one end of his anti-Aristotelian physics, and a small, albeit core element of his scientific interests. His other work in physics includes the study of bodies in free fall (closely modeled on Galileo's work), a mature enunciation of the principle of inertia, and an early and reasonably accurate interpretation of the Pascalian barometry experiments of the late 1640s. Gassendi also ventured into experimental science: he attempted to measure the speed of sound by cannon fire, arranged to have weights dropped from the mast of a moving ship off Marseille to enact Galileo's thought experiment (and so dispel doubts about the motion of the Earth), and conducted numerous chemical trials involving, among other things, the dissolution of salts and formation of crystals (to bolster his molecular theory of matter); these are only some of his better-known exploits. In addition, he offered a wide variety of speculations on the earth sciences based partly on geological fieldwork and biological and physiological observations—and as shaped by his atomist hypothesis. Finally, Gassendi devoted much of his time to astronomical pursuits. He made regular observations of the skies for decades, in an effort to lend credence to Kepler's views, and in so doing he observed the rings of Saturn and the passage of Mercury before the Sun (1631)

and successfully predicted an eclipse in 1654. Moreover, he commissioned the first map of the moon (drawn on the basis of his observations), defended the Copernican view as plausible save for its conflicts with Church teachings (he opted for the Tychean view, at least publicly, as a result), and offered many disparaging words on what he considered the scurrilous practice of astrology.

In his final years, Gassendi relented to pressure from his friends and released a major portion of his Epicurean studies to the public, publishing his Latin translation of Diogenes Laertius's Book X on Epicurus, along with ample commentary, in his *Animadversiones* of 1649. He continued to work on this interpretive material, however, steadily incorporating his philosophical and scientific insights, until his death in the Paris apartment of Montmor in 1655. Montmor, acting as executor, collected this material in manuscript form and with Gassendi's other Parisian friends arranged to have it published as the posthumous *Syntagma Philosophicum*. The *Syntagma* is more systematic than the *Animadversiones*, largely eschewing the sometimes philological character of the earlier commentary and principally discussing logic, the natural sciences, psychology, and ethics from the perspective of what he deems philosophically, historically, and theologically supportable. His interests in Epicurus are ever-present, not least in the structure of the work, which is divided into a Logic (including his textbook-format *Institutio Logica*), Physics, and Ethics.<sup>5</sup>

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<sup>5</sup> One may conceive of Gassendi's Epicurean project as his having rewritten portions of the same book several times over—first the *De vita et moribus Epicuri* (1647), then the *Syntagma Philosophiae Epicuri* (1649) and *Animadversiones* (1649), then the *Syntagma* (1658), with various manuscripts en route, as well as large segments of his correspondence to Valois; q.v. Rochot (1944); Jones (1981); and Carla Rita Palmerino, "Pierre Gassendi's *De Philosophia Epicuri Universi* Rediscovered", *Nuncius* 14 (1999), 263–295.

If such a gloss is even vaguely accurate, then there is sufficient reason to focus on the *Syntagma* as the most considered—if not necessarily most refined—Epicurean view that Gassendi develops. Antonia LoLordo (2005b) suggests that this judgment is all the more warranted given that the *Animadversiones* is composed as a commentary whereas the *Syntagma* offers Gassendi's views in more manifest fashion; q.v. "The Activity of Matter in Gassendi's Physics", in *Oxford Studies in Early Modern Philosophy* 2, ed. Dan Garber & Steven Nadler (2005b), 75–103.

Accordingly, I take the *Syntagma* to constitute the philosophical document of record, or Gassendi's considered view. In most cases, this is a wholly unproblematic, in the sense that Gassendi tends to an overall consistency over the course of the years. One prominent exception is the *Exercitationes* (1624), his first work and a polemic against Aristotelianism in which he expresses great doubts about the possibility of, among other things, causal reasoning on the model of the Stagirite; q.v. discussion below.



Happily, we have a rather well rounded picture of Gassendi's intellectual pursuits, on top of his Epicurean projects. Montmor and company had the good sense to bundle the *Syntagma* together with the better part of Gassendi's other writings (the *Animadversiones* notably excepted) in six volumes of collected works, the *Opera Omnia* (Lyon, 1658; Florence, 1727), which includes as well earlier letters on optics and the free fall of bodies, a portion of his voluminous astronomical observations, and a great deal of his correspondence.<sup>6</sup>

In the wake of his death, Gassendi's general renown, his influence on French schooling and popular conceptions of natural science, and his rivalry for Descartes' legacy, all grew. This was likely the result of the 1674–1675 publication of a condensed, abridged, reorganized, and occasionally paraphrased version of the *Opera Omnia*, written in French by Gassendi's acolyte, François Bernier. Over the following half century, the “Gassendistes” stood as formidable opponents to the “Cartésiennes” in French debates over educational and scientific matters, and Gassendi's thinking spread—variously influencing Leibniz, Boyle, Locke, and Newton, among others.<sup>7</sup>

## 2. *Philosophical Highlights*

In this study I focus on Gassendi's atomist hypothesis, his theories of empirical knowledge and scientific method, and the relations

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There are two reasons to focus, in a study of this sort, on the writings *after* the *Exercitationes*. The first is that Gassendi himself abandoned that eight volume project after only two volumes, and after publishing only one of those. One motive frequently cited for this is that his anti-Aristotelianism, if continued apace, promised to get him into trouble. Another motive is that he subsequently launched his Epicurean project—his commitment to which simply sidelined any competing endeavors. The merits of these motives aside, for Gassendi to not have continued the project of the *Exercitationes* it is sufficient that he changed his mind about at least some of those views. Where we see those changes we may well take the latter views to be those of record—particularly where he states them in multiple places.

<sup>6</sup> There is only one modern full-length biography of Gassendi—Jones (1981)—and this relies greatly on Gassendi's writings and known correspondence. A recent translation of the correspondence is accompanied by an extensive introduction with detailed biographical notes; q.v. Taussig (2003). An early and frequently-cited (but not entirely reliable) predecessor is Joseph Bougerel, *Vie de Pierre Gassendi, prévôt de l'église de Digne et Professeur de Mathématiques au Collège Royal* (Paris: Jacques Vincent, 1737; Reprint edition, Geneva: Slatkine Reprint, 1970).

<sup>7</sup> This French debate is documented in detail by Lennon (1993); further and disparate influences of Gassendi are discussed in Sylvia Murr (ed.), *Gassendi et L'Europe (1592–1792)*, Paris: J. Vrin, 1997.

between these views. Many commentators identify his paramount contributions to philosophy as including his advances in epistemology—development of an empiricist theory of knowledge and a set of ‘constructive’ or ‘mitigated’ skepticist theses, as well as his objections to Descartes’s *Meditations*. In those well-known objections, he seeks to refute the clarity and distinctness criterion and undermine the reasoning behind the *cogito*. As background and context I review chief elements of these highly touted views, with a particular eye towards grasping the perspectives Gassendi viewed himself to be contesting. I discuss Gassendi’s theory of empirical knowledge at length in Part One. Here I contrast his root empiricist claim—that all knowledge comes from the senses—with the Aristotelian perspective shaping the scholastic received view of his day, and with cartesian perspectives representing the much acclaimed alternative to that received view.

The central claim of Aristotle’s empirical knowledge theory is that we may know universal truths about natural kinds in the world, through a combination of observational experience, intellectual intuition, and logical demonstration. The principal framework for attaining all knowledge (including what we know of the external world) is through the use of demonstration and the syllogism. Aristotle and like-minded scholastics hold that a body of knowledge built on syllogism requires well-grounded initial premises in the form of fundamental principles. Accordingly, knowledge in general begins with what they consider to be universal and necessary principles, such as a principle of non-contradiction. Empirical knowledge thus begins with universal principles relating the essences of forms of objects in the world, such as “all As are Bs”. But we can only know principles like “all As are Bs” about worldly objects if we have ‘real’ definitions giving the essences of such objects. Otherwise we could not be certain about the necessity of any A and B having those properties  $f$  that would make all As Bs. The proposal is that we get such real definitions by induction on our particular experiences (observations of individuals of a given kind having properties  $f$ ) plus acts of the intellect where we intuit, as a real definition of individuals of some kind  $y$ , the essence  $x$  from which it follows that  $y$ s have  $f$  essentially.

According to this view, the goal of empirical knowledge—and, in particular, what we have come to think of science—is the organization of real definitions in a branched hierarchy (‘tree of porphyry’) which, giving the relations of sorts of things relative to their essential prop-

erties, maps the natural kinds. This grand picture of scientific knowledge as an account of immutable and underlying natures rests on the suggestion that we can get from induction on particulars to universal claims of a necessary nature. The justification for this move seems to be that the ‘right’ induction is somehow persuasive and our powers of intuition enable us to spot a real definition when we are presented with the right inductive arguments.<sup>8</sup> Hence we attain scientific knowledge—and, more generally, empirical knowledge—by employing (universal) principles of reasoning to calculate the relations between universal empirical principles and our beliefs about particular specimens or instances, each of which we base ultimately on individual empirical experiences.

Underlying this view of empirical and scientific knowledge are at least two metaphysical assumptions, that the world is carved into the sort of neat substances Aristotle posits, and that the kind of substance a thing is, is determined by some immutable essence.<sup>9</sup> In addition, Aristotle presumes we have some epistemic access to those essences such that we can determine the real definitions of substances. Given these sizable assumptions, the principal problem Aristotle leaves us with concerning empirical knowledge is how to connect up our experiential data with his demonstrative picture of the sciences, that is, how to lend precision to his suggestion that we ‘intuit’ universals on the basis of inductions on our data.

In the cartesian picture of empirical knowledge we find an attempt to work out something like this last problem of Aristotle’s. Descartes agrees that we know about the world through reason: necessary laws govern the relations between objects and the necessary features of substances tell us about the underlying reality of the world. Further, and in further agreement with Aristotle, perceptual knowledge concerning objects cannot give us a true picture of these necessary laws or features, so we must rely on knowledge from reason alone to arrive at these truths and reveal their relations, through deductive logic. At the same time—again, per Descartes and Aristotle—

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<sup>8</sup> Though the connection between the universal and the necessary is of course tenuous, Aristotle does not talk about the possibility of intuiting contingent universal truths, no doubt because he is a firm believer in natural kinds.

<sup>9</sup> I employ ‘essence’ here to refer to the Aristotelian underlying defining character of a thing; ‘essential characteristics’ accordingly refer to the elements which comprise that character.

perceptual data are greatly important to the attainment of empirical knowledge. There is a body of claims about the world we may strive to improve regarding appearances—not underlying reality *per se*—and any such science of appearances (and our collection of justified empirical beliefs generally) relies on information from the senses. Our sets of beliefs about appearances and about their underlying reality come together when we structure the empirically-derived beliefs as theoretical claims related by deductive proof. Descartes's suggestion is that geometry models our empirical beliefs concerning shape and motion in just this way, and that the rest of our empirical beliefs can either be subsumed under geometric argument or else under similarly deductive arguments with the support of a few central first metaphysical principles—a project he tries to sketch in the *Principles of Philosophy*. This approach at once widens and bridges the gap between an inductivist view of perceptually-based empirical judgments and any deductivist edifice of beliefs about the way the world 'really is'. On one hand, Descartes suggests there is no necessary connection between knowledge of appearances and knowledge of physical or metaphysical 'reality'—our sensory-based knowledge of appearances is particular to our perspectives whereas our reason-based knowledge is not. Yet he also proposes how we may fit sensory-based beliefs into the deductivist structure of our metaphysical and physical theories. In contrast with Aristotle, Descartes tries to minimize his reliance on intellectual intuition for putting together the two kinds of beliefs. Instead, he places faith in the incontestability of geometric and other deductive reasoning, and the particular basic metaphysical principles he ordains. Both sets of beliefs meet his proposed truth-criteria<sup>10</sup> of being clear and distinct, Descartes argues, and thereby yield a rational framework for those truths we arrive at through observation and experiment.

Some of Descartes's assumptions here bear a surprising affinity to suggestions made by Aristotle—for example, that there are necessary laws and features in the world just waiting to be discovered by us, and that we can arrive at certain knowledge about such necessary aspects of the world given pure *a priori* reasoning about the matter. In addition, Descartes proposes that knowledge of appearances helps

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<sup>10</sup> Descartes may intend clarity and distinctness not so much as a criterion *per se* of truth as a standard for epistemic warrant—the sort of thing John Pollock calls a 'justificatory norm'.

guide our choice of the right deductive account of necessity in nature, and this proposal rests on (among other things) his particular deductivist account of the sciences and background truth-criteria.

Gassendi, too, has concerns about the Aristotelian view but does not believe they are resolved by Descartes. For one, Gassendi is not convinced that there is anything necessary about the way the world is. God, he proposes, could have made the world work in any number of ways, and the contingent history and character of Creation means that there is nothing immutable about the essence of a material thing.<sup>11</sup> For another, Gassendi maintains that, regardless of whether there are any essences and whether they might be mutable, there are none to which we have any epistemic access. The sole originating source of our knowledge is the information our senses provide, and so what we know is closely linked to what we can perceive. However, as Descartes notes, we can perceive only appearances, and Gassendi draws from this point the very uncartesian lesson that this is all we can know about, too—thereby ruling out knowledge of unperceivable essences. One line of this reasoning can be found in his discussion of classical skeptical tropes concerning the relativity of evidence from the senses to individual experience—that honey tastes sweet to me, though bitter to you; and that fire seems hot to us, though not so to insects that live near fire.<sup>12</sup> Since different people have distinct experiences, our knowledge of honey’s taste or fire’s heat differs from person to person and thus is not a reliable guide to invariable characteristics of, for example, the honey or fire. In cases like these we know a thing’s qualities only as we record them on a subjective basis, and such sensory information where our experiences vary intersubjectively cannot yield judgments about the thing’s qualities which do not vary in that (or any other) way. Hence we lack knowledge of the thing’s essence—if indeed there is one. More broadly, from our principal source of ideas—the senses—we know only how things appear to us.<sup>13</sup>

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<sup>11</sup> That a ‘substance’, in either the Aristotelian or cartesian sense, might have an immutable essence, is a different matter, and insofar as Gassendi has such a notion (for example, with respect to space, time, matter, and void) he agrees that such things feature unchangeable *sine qua non* characteristics.

<sup>12</sup> *O III (DM)* 388b; *R* 535.

<sup>13</sup> If we are to have knowledge of an object’s essence, Gassendi proposes, such requires a “perfect interior examination” of that object, which is apparently not something we may gain from empirical study (*O III (DM)* 311b–312a; *R* 184).

Moreover, Gassendi throws out the Aristotelian set of views on knowledge of universals, on the grounds that we cannot perceive anything more than particulars in the world.<sup>14</sup> It follows, he suggests, that neither can there be any universals we know about, at least with anything like certainty. Indeed, Gassendi's insistence that all knowledge comes from the senses leads him to reject the view (shared by Descartes and Aristotle) that there are *any* propositions we can know with certainty. Since all propositions are judged as true or false on an empirical basis, none can be deemed indubitable, save those of theology and theologically-derived cosmology.

This Gassendist lack of certainty extends as well to logical demonstration, whether of inductive or deductive character. There is nothing certain about such demonstration, Gassendi suggests, save the limits imposed upon it by the frailty of human intellectual capacities. The natural bounds of our epistemic grasp in the physical sciences, astronomy, or most any other field of study is just what the senses tell us, plus any correctives reason supplies on the basis of sensory-based knowledge we have already accrued.

That Gassendi thinks there is a need for correctives on sensory information makes clear the depths of his rejection of the epistemic foundationalism we find in Aristotle or Descartes: we cannot trust even information from the senses to give us a failsafe picture of the world. In this he embraces the Skeptical judgment that no source of our beliefs can provide us with certain knowledge. Yet he cannot accept their wholesale dismissal of sensory-derived evidence for belief. He suggests that we indeed have knowledge from the senses just in case we have warrant for our judgments about appearances, even though we may lack warrant for certainty about those judgments. To the limited extent that we have the second sort of warrant, he suggests, we find this in the reliability of our sensory apparatuses (as he describes in his Epicurean-inspired account of perception). In sum, Gassendi develops a 'constructive skepticist' response to the skeptics who say no knowledge is possible and to those ancient and latter-day 'dogmatic' thinkers (including, in his view, Aristotle and Descartes) who say knowledge involves the attainment of certain belief—and is readily attainable. His response is that while it may not be possible to have certain beliefs it is quite possible to

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<sup>14</sup> *O* III (Exercitationes) 159a; *EP* 280–281. Cf. Osler (1994), 113–115.

have knowledge given that we construe it as justified but less-than-certain belief.<sup>15</sup>

Gassendi most clearly articulated his disagreements with Descartes in his *Objections to the Meditations*,<sup>16</sup> where he forcefully rejects the cartesian criterion of clarity and distinctness, as either a standard for judging ideas or source of epistemic warrant. As regards the former, Gassendi points out that reason, which comprises our intellectual judgments and interpretations of sensory information, is itself prone to error:

... although deception, or falsity, is not to be found in the senses themselves, which merely behave passively and only report things as they appear and as they must appear given their causes, it is to be found in the judgment, or mind, when it does not act with enough circumspection and does not perceive that things which are distant ... appear more indistinct and smaller than they do close up. ...<sup>17</sup>

If, for all their faults, claims based on sensory information are more reliable than those based on reasoning (about sensory information or anything else), then we ought not appeal to the latter as a basis for judging among claims of the former. One reason he thinks claims based on sensory information are the more reliable of the two is that he takes the senses to passively (hence steadily) collect information, in contrast to our mental judgment actively (hence irregularly) organizing or relating information.<sup>18</sup>

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<sup>15</sup> Naturally, it must have a veridical character as well, and Gassendi thinks it sufficient that such beliefs are at least truth-resembling; see chapter two.

<sup>16</sup> In his initial criticisms and subsequent response to Descartes's replies, Gassendi offers a number of crucial and enduring points against the argumentation of the *Meditations*, though not necessarily the claims (for example, as regards the existence of God). Q.v. Olivier René Bloch, "Gassendi Critique de Descartes", *Revue Philosophique de la France et de l'Étranger* 156 (1966), 217–236; Thomas M. Lennon, "Pandora; or, Essence and Reference: Gassendi's Nominalist Objection and Descartes' Realist Reply", in *Descartes and his Contemporaries: Meditations, Objections, and Replies*, ed. Roger Ariew and Marjorie Grene (Chicago: University of Chicago Press, 1995), 159–181; and Catherine Wilson, *Descartes' Meditations: An Introduction* (Cambridge: Cambridge University Press, 2004).

<sup>17</sup> *O* III (*DM*) 388a; *R* 532; *B* 266–267.

<sup>18</sup> He does not deny that we may have problems gauging the warrant for claims based on sensory information as we collect it. Rather, he insists that we will have even more problems when the claims we gauge are based on ideas about sensory information after we have removed it from a direct and perspicuous relationship to the world as experienced, by organizing and relating it in various ways to other ideas.

Further, the cartesian criterion is irrelevant to judging cases of empirical knowledge, Gassendi suggests—and even if this criterion were not irrelevant, Descartes’s own claims to knowledge should fail all the same. First, in the case of empirical knowledge, Gassendi counters that the cartesian criterion fails on classical skeptical grounds: it is possible for us to have ideas from the senses we take to be clear and distinct which are nevertheless not the basis for warranted claims to empirical knowledge of a general nature. Though we may have clear and distinct ideas about the appearances of, for example, the color of the sky we perceive, we cannot infer from this clarity and distinctness that we know what color the sky is. As the skeptics warn, the sky could appear to different persons in different colors, and as Gassendi adds, our ideas of such an appearance could each be clear and distinct.<sup>19</sup> Second, knowledge claims Descartes takes to be demonstrated by reason alone Gassendi dismisses as anyway failing the proposed criterion; they are partial and confused, he suggests, because they lack the immediacy characteristic of judgments we attain by strictly empirical means. Whereas ideas we gain from the senses directly represent worldly objects and events, ideas we attain by deductive proof are but hypothetical analogues to such sensory-derived ideas:

... it is not the same thing for us to conceive something by a veritable idea or a true image, and to conceive that thing by a conclusion that follows necessarily from an anterior hypothesis. In the first case in effect we conceive of the thing as absolutely so; in the second, that it should be some such thing; and also in the first case we know the thing distinctly and as it is in itself, and in the second case we know it only in a confused manner and by analogy, that is, in referring to it as something that must be known by way of some idea.<sup>20</sup>

In brief, our reasoned claims are less than fully clear or distinct because we arrive at them through the mediation of ideas about our empirical knowledge. Hence Descartes’s most cherished claims about essential properties of mind, God, and matter fail his own criterion for lack of direct foundation in our ideas from the senses.

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<sup>19</sup> *O III (DM)* 314b; *R* 198–199.

<sup>20</sup> *O III (DM)* 322b; *R* 234. In this passage Gassendi contrasts the ideas or images of an object we attain directly from the senses with those ideas or images of the same that we infer from the ideas we attain directly.



Not all of Gassendi's criticisms of the clarity and distinctness criterion are rooted in his advocacy of knowledge from the senses. Thus, Gassendi suggests one other problem with the cartesian criterion is that it cannot make good on its foundationalist promise. Just in case some of our clear and distinct ideas turn out to be wrong, we will require some further criterion to distinguish them from the correct ideas. And if the new criterion is simply something like 'more clear and more distinct', then we are on the road to infinitely many higher-order criteria, which defeats the aims of the foundationalist project altogether. Finally, Gassendi offers what Descartes himself came to call "the objection of objections." That our ideas are clear and distinct is perfectly consonant with a solipsistic perspective, but then the only thing we can know with certainty is our own thoughts. Yet a viable criterion should (a) also distinguish our knowledge claims about the external world, and (b) mark solipsistic claims as dubitable to begin with. On top of these objections, Gassendi proposes that Descartes has put the cart before the horse by suggesting we can readily recognize what is clear and distinct and use this as a guide to what is indubitable when what we need in the first place is some guide as to what is clear and distinct.<sup>21</sup>

Finally, a sketch of Gassendi's main philosophical disagreements with Descartes must also take note of his famous objections against the cartesian views on mind and body. One such objection is a natural prelude to the well-known puzzle over how mind and body could be thought to interact, posed by Princess Elizabeth of Bohemia. Gassendi wonders how Descartes could take the mind to be thinking substance which lacks extension yet claim that it is somehow attached to the body, given that anything joined to a body must itself be extended.<sup>22</sup> Descartes's answer is that he does not take mind and body to be attached, and this response immediately invites Princess Elizabeth's puzzle.

A second objection is leveled directly against Descartes's *cogito* reasoning. Gassendi understands this reasoning as one person's inference from his or her indubitable recognition of cognitive activity, to

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<sup>21</sup> "... the difficulty is not, as it seems, to know if one must conceive things clearly and distinctly so as not to be mistaken at all, but to know by what way or method it is possible to recognize that one has a conception so clear and so distinct that it is true and impossible that we are mistaken." (*O* III (*DM*) 372b; *R* 458)

<sup>22</sup> *O* III (*DM*) 399b–401a; *R* 584–590.

the claim that he or she exists as the selfsame seat of such activity. Against this inference he points out that the recognition that one has a set of thoughts does not imply that one is a particular thinker or another. Were we to move from the observation that there is thinking occurring to the attribution of this thinking to a particular agent, we would simply assume what we set out to prove, namely, that there exists a particular person endowed with the capacity for thought.<sup>23</sup> Descartes is in dangerous waters at this point, for if indeed the only claim that is indubitable here is the agent-independent claim that there is cognitive activity present, then he can be fairly associated with Averroist panpsychism, with its considerable taint. At a minimum, the argument requires a significant leap of reasoning, and for Gassendi, this is further evidence that Descartes places altogether too much faith in his criterion and the work he thinks it can do. That Gassendi is primarily concerned here with the character of Descartes's reasoning is plain enough: in the end and broadly speaking, the two are close in their views about mind and body. They are both dualists of one stripe or another, and the particulars of Gassendi's physically-rooted psychology are reasonably similar to those of Descartes's model.<sup>24</sup>

### 3. *Gassendi at the Cusp of Modern Thought*

Given Gassendi's engagement with Aristotle and early (as well as late) Aristotelianism, and his great debts to Skeptic, Stoic, and Epicurean thought, it may seem appropriate to think of Gassendi as belonging to the learned ways of Renaissance philosophy, rather than to the radical changes marking the early modern era. Commentators and historians conventionally consider him as an early modern thinker yet there is good reason to see him as at least a borderline figure, and much recent scholarship reflects this characterization. One facet of his work that closely resembles Renaissance philosophy and science is the

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<sup>23</sup> *O* III (*DM*) 289a–290a; *R* 82–86.

<sup>24</sup> On the other hand, for differences separating them, see Emily Michael and Fred S. Michael, "Two Early Modern Concepts of Mind: Reflecting Substance vs. Thinking Substance", *Journal of the History of Philosophy* 27 (1989), 29–48; and Antonia LoLordo, "Gassendi on Human Knowledge of the Mind", *Archiv für Geschichte die Philosophie* 87 (2005a), 1–21.

historical focus of his method of inquiry. For almost every philosophical issue Gassendi deems worthy of discussion, he first introduces a wide range of previous competing views, beginning with the antique schools, which he considers as 'live' options. The history of philosophy is for him a source of vitally important reasoning, the generally correct way to frame our questions, and more occasionally, the answers to those questions. Thus, as I argue in chapter nine, one principal attraction of atomism for Gassendi is that it suggests a way to think about causation among material objects which he finds an attractive alternative to Aristotelian views on one hand and non-physicalist views on the other. In his theory of knowledge we find one more instance of using ancient frameworks to model contemporary problems: no criterion of truth, for example, is adequate unless it satisfies the standard points made by the classical skeptics. Ironically, some might see this as evidence of Gassendi's modernism, but his broad concerns with skeptical thought certainly place him among good Renaissance company.

Another Renaissance-type element of Gassendi's writings is his stylistic obsession with antiquity. His Latin is learned if a bit stultified, and this embroidered, ornate quality marks his French, too. He quotes frequently and liberally from classical sources, usually in Latin though sometimes in Greek, and his translation of Diogenes Laertius's Book X on the life of Epicurus is the centerpiece of his 1649 *Animadversiones*. Gassendi does not, as does Descartes, suggest his work is so modern as to have been invented *de novo*; rather, he constantly refers the reader to a wide variety of other, generally classical writers as sources of both agreeing and differing perspectives. Finally, the single most time-consuming project of his career consists in his prodigious efforts towards reviving the works and reputation of one particular classical figure, Epicurus. It is hardly surprising that much recent Gassendi literature highlights his classical interests.<sup>25</sup>

While these Renaissance trappings are a key facet of Gassendi's work, there are at least two reasons to think of Gassendi as very much among the moderns. For one, he embraces the new empiricist's assessment of the old science: what is wrong with the Aristotelians'

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<sup>25</sup> One notable suggestion of recent commentary is that Gassendi's understanding of Epicurus is shaped by Stoic sources—principally Seneca and Cicero; q.v. Brundell (1987) and Taussig (2003).

physics is its routine presentation, as well as grounding, in *a priori* theoretical claims. Galileo is among the first to distinguish a contrasting science of motion that, in principle at least, makes use of observation and experiment, and Bacon and Descartes also counsel (to varying degrees) a scientific method which builds on experiential knowledge. But among the *savants* of the early seventeenth century, only Gassendi, whose awareness of empiricism's roots and implications is evident across his intellectual pursuits, integrates philosophy and science on what he believes to be strictly empiricist grounds. This integration is a natural consequence of his suggestion that we gain all knowledge (outside of the theological) from the senses.

A range of equally modern views follow from his proposed empiricist foundations for the new science and its methods. As I explore in chapters two and three, he suggests a probabilist notion of what counts as warranted empirical belief, and insists that we may license beliefs about the sub- and supra-perceivable but only if they are well-grounded in our beliefs about the perceptually given. Further, he devises rules for accepting or rejecting hypotheses, and guidelines for directing empirical discoveries and our judgments of the same, where all such claims are subject to the test of evidence from experiment or observation (q.v. chapter six). It is far from true that all, or even most, of his own claims about the nature of the physical world meet this test, but the modernity of Gassendi's philosophy and science lies in his proposal that this is a goal to be set, altogether.

PART I

A CONSTRUCTIVE SKEPTICIST THEORY OF  
EMPIRICAL KNOWLEDGE



## CHAPTER ONE

### THE SKEPTICAL CHALLENGE, AN EMPIRICIST RESPONSE, AND A PHYSICALIST THEORY OF PERCEPTUAL BELIEF

We best understand Gassendi's theory of empirical knowledge—indeed, his entire epistemological project—as an attempt to resolve skeptical worries by advancing truth-criteria and elements of epistemic warrant that he describes in the physicalist terms of his account of sensory perception and the formation of ideas. Ever the historian of philosophy, he further develops this modern Epicurean theory of knowledge in a bid to reject an Aristotelian picture of essentialist empirical belief. He also relies on this theory to counter Descartes's cognitive and epistemological views. Yet this account of how we gain all knowledge through the senses is not just an echo of ancient philosophy or a foil Gassendi wields against adversaries past and present. It is the product of his considered views concerning perception, ideas, truth, and justification. On the basis of these views, he responds to Skeptics, Scholastics, and Descartes alike that we can have warranted empirical beliefs without certainty, based on trustworthy evidence from the senses. This last, broad claim stands or falls, however, not so much as it fares as a response to Gassendi's adversaries, but as fare his arguments for a theory of warrant for empirical knowledge, the constituent proto-reliabilist and probabilist claims, and the background principles underlying those claims. Specifically, his theory suggests that empirical beliefs are warranted just in case the evidence for them is gathered in generally reliable fashion and does not conflict with accepted evidentiary experiences, and that we can have warrant for empirical beliefs though we cannot be wholly certain of them. For Gassendi, these claims follow from core elements of his views on cognition and the truth and justification of belief, including his proposals that the mind receives sensory information through a wholly physical process, that some perceptual givens serve as tools of inference which license warranted claims about physical phenomena to which we have no direct sensory access, and that we can use cognitive faculties to judge the truth of empirical beliefs because those faculties dependably allow us to detect truth properties of the objects of knowledge.

*The Background Skeptical Challenge*

We typically and intuitively accept that our perceptions of appearances tell us *something* about the world, if only how the world appears to us. The well-worn philosophical question is whether such perceptions yield warranted claims about the way the world actually is, beyond appearances. If we accept that knowledge minimally comprises beliefs that are justified and true, then the primary puzzles of perceptual knowledge arise in articulating the justification of beliefs we base on perception and the criteria for the truth of such beliefs. These challenges are outlined early in the history of Western philosophy by the ancient Skeptics, who propose that we face great obstacles in trying to identify either a truth-criterion or the proper warrant for taking any beliefs (empirical or otherwise) as instances of knowledge. Indeed, they suggest our inability to find warrant for our beliefs is a result of our inability to locate a truth-criterion. Having such a criterion is understood as a necessary component of coming to beliefs for which we have good reasons, one good reason apparently being that the belief is judged to be true.<sup>1</sup> Lacking a means of distinguishing true and false claims, we ought not invest belief in any of them but instead suspend our judgment as a means of attaining mental composure and tranquility (*ataraxia*).<sup>2</sup>

Thus the basic problem posed by the Skeptics with respect to empirical judgments is how and why we can call our claims about the world certain knowledge. In reaction to the classical view—

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<sup>1</sup> It is not clear why the Skeptics include knowing that *p* is true as a necessary condition for taking *p* to be justified (that is, as a necessary reason for *p*) given that we frequently have beliefs we take to be justified that turn out to be false though we remain justified in retrospect, for example, given our background information at the time. A response here might be that, just as we recognize what we previously took to be true as false, we should recognize what we previously took to be justified was in fact not so. A problem with this response is that we can be genuinely wrong about beliefs being true, but given that we meet the relevant justification standards it is hard to see how we could be wrong about being justified.

<sup>2</sup> The classical Skeptic texts appear in Julia Annas & Jonathan Barnes (eds.), *The Modes of Skepticism: Ancient Texts and Modern Interpretations* (Cambridge and New York: Cambridge University Press, 1985); recent commentaries include Miles Burnyeat, “The Sceptic in his Place and Time”, in *Philosophy in History: Essays on the Historiography of Philosophy*, ed. Richard Rorty, J.B. Schneewind & Quentin Skinner (Cambridge and New York: Cambridge University Press, 1984), 225–254; Malcolm Schofield, Myles Burnyeat & Jonathan Barnes (eds.), *Doubts and Dogmatism* (Oxford: The Clarendon Press, 1980); and Benson Mates, *The Skeptic Way: Sextus Empiricus’s Outlines of Pyrrhonism* (Oxford and New York: Oxford University Press, 1995).



promulgated by Aristotle and the Stoics, among others—that evidence from the senses lends sufficient warrant to our empirical beliefs, the Skeptics call such affirmation sheer dogma. They counter that we lack a criterion for differentiating true and false claims based on evidence from the senses and that even if we had such a criterion, we would still lack absolute assurance that any of these claims are certain.<sup>3</sup> The most we can say about sensory evidence, they suggest, is that it gives us justified beliefs about the way things appear to us.

Possible responses to the challenge posed by the Skeptics include those that define the epistemic judgments to which we are entitled,

- (a) lacking truth-criteria, justification, or both, for our beliefs,
- (b) lacking absolute justification, but not some more limited warrant, for our beliefs (so that we may not know them with certainty),  
or
- (c) given some truth-criterion and absolute justification for our beliefs (so that we know them if and only if we are certain of them),

and how it is we are entitled to such beliefs.

The first possible response entails working wholly within the skeptical framework: we do not dismiss the Skeptic's doubts about the strength of our beliefs, even if we take those beliefs to be either justifiable or plausibly identified as true. The third possibility, which the Skeptics held to be emblematic of 'dogmatism', represents the utter rejection of systematic doubt and, correspondingly, the assertion that we have the capacity to satisfy the primary conditions for knowledge with certainty. We find this view in Aristotle and in Descartes, for whom justification of empirical beliefs is a special problem generated by maintaining an essentialist metaphysics in combination with faith in our ability, partly through experience, to know with certainty the ultimate structure of the world. For at least some empirical beliefs, they suggest, it is not only the case that we can be certain of them; these beliefs also provide us with a sure grasp of the essential nature of things. The difficulty lies in providing the

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<sup>3</sup> The Pyrrhonians who precede the Skeptics of the Academy and the Post-Academics (including Sextus Empiricus) point out that if we have no justification for saying that we know something with certainty, then we can no more justify our claims against the possibility of certain knowledge than we can the claims for it. They conclude that we should suspend judgment even about the question of whether or not we can attain knowledge.

warrant for such beliefs. It was clear to Skeptics like Sextus Empiricus that Aristotle's theory of empirical knowledge failed in this regard, and Descartes took it to be one of his tasks to show the Skeptics wrong for thinking such warrant unfindable.

By contrast, the second possible response suggests that, against the Skeptics—but also against the Aristotelian or cartesian responses—our beliefs may be justified independent of whether the warrant for them is absolute, entitling us to believe them with certainty. One instance of this kind of response, developed in the wake of the Reformation, contests the way the Skeptics conceive of the problem of empirical knowledge—though the view is often thought of as a species of skepticism itself.<sup>4</sup> This is 'constructive' or 'mitigated' skepticism, the view that ancient Skeptics were *right* to claim that the senses may not yield certain knowledge but *wrong* to suggest that knowledge of the world depends on its certainty and that knowing appearances cannot yield knowledge of the world.<sup>5</sup> To the contrary, the constructive skeptic argues that the very character of sensory evidence such as we perceive it warrants our empirical judgments. As a first step, the Skeptic's quest for epistemic warrant is divided into the search for justification for taking beliefs to be certain on one hand, and reliable on the other. The Skeptic takes beliefs about which we are certain to be the only reliable kind, and concludes that the search in either case is futile. By distinguishing between epistemic certainty and reliability, the constructive skeptic can agree with the (traditional) Skeptic that we may not find warrant for certain knowledge, yet affirm that we can attain reliable knowledge. Whereas the Skeptic doubts we can identify a fixed or stable criterion for identifying true empirical beliefs in individual instances, much less a means of appraising their reliability (across instances), the constructive skeptic holds out the possibility of a feasible truth criterion and defends our perceptual grasp of the world as stable and

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<sup>4</sup> Though texts of the ancient Skeptics were generally lost or not read during the Middle Ages, interest in skepticism was revived in the West in various forms during the Renaissance. The writings of al-Ghazali and Yehuda Halevi indicate that the disappearance of Greek and Roman texts in Latin Europe did not mean an absence of skeptical thought in medieval times; q.v. Popkin (2003).

<sup>5</sup> The terms 'constructive skepticism' and 'mitigated skepticism' are nowadays closely associated with Popkin's historical analysis; the term 'mitigated scepticism' in particular was devised by David Hume; q.v. *An Enquiry concerning Human Understanding* (1777), ed. P.N. Nidditch, Third edition (Oxford: The Clarendon Press, 1975), 162.

regular enough for us to build, and gauge the merits of, our empirical understanding. This is not likely to satisfy the Skeptic, for whom both faculty- and belief-based truth-criteria fail because they rely on our fallible senses and for whom information about appearances depends greatly on personal and contextual factors, yielding neither reliable nor consistent empirical claims (though we rely on such appearances to record individual sensations of material phenomena). Against such epistemic pessimism, the principal task of the constructive skeptic is to explain what it is about our sensory faculties, acts of sensation, and beliefs we base on those acts, that lends a discernable character of truth to such beliefs and renders them sufficiently reliable to build an abstract understanding of the world—beyond the particulars of individual sensory perceptions.

This is the task that Gassendi sets for himself.<sup>6</sup> In his *Exercitationes Paradoxicae* (1624), he endorses the Pyrrhonian proposal that we cannot know with certainty about the world thus we are justified only in suspending our empirical judgments.<sup>7</sup> Yet in the later *Disquisitiones Metaphysicae* (1644) and *Syntagma Philosophicum* (1658) he mitigates that earlier Pyrrhonism, by differentiating between certain and probable knowledge, and suggesting that the latter in particular is readily attainable given trustworthy sensory evidence. Though all beliefs about the world are subject to revision, we can have a dependable—and in some cases, even indubitable—understanding of sensible phenomena because the physical characteristics of perception guarantee that our sensory data approximate the apparent features of the world they represent. This in turn lends verisimilitude and reliability to beliefs we found on their basis. Further, we can identify the cognitive faculties which, by their constitution, enable us to pick out true and false empirical beliefs. Gassendi maintains principled skeptical doubts about knowing the innermost structure of reality—he holds that we cannot know with certainty about the basic and constituent elements and relations of physical things. Yet he rejects the anti-empiricist strain in classical Skepticism. Instead, Gassendi looks to Epicurean themes and his own research on the optics of perception to craft a

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<sup>6</sup> Among Gassendi's recent predecessors and contemporaries, commentators have counted Francisco Sanchez and Marin Mersenne as fellow constructive skeptics; q.v. Popkin (2003) and Susan James, "Certain and Less Certain Knowledge", *Proceedings of the Aristotelian Society* 87 (1987), 227–242.

<sup>7</sup> *O III* (*Exercitationes*) 182b–183a; *EP* 388–393. Q.v. Popkin (2003), 144–46.

balance of doubts about certain knowledge of essences on the one hand, and arguments for cognitive truth-criteria and reliabilist warrant for empirical belief, on the other.

*Gassendi's Constructive Skepticism*

We find Gassendi's mature response to skepticism and his developed theory of empirical knowledge in his writings from the period after he launches his exploration of Epicurus—and principally in the *Disquisitio* and the *Syntagma*. In these later writings, he proposes that appearances reliably represent features of worldly objects and phenomena given that the senses provide us with what are—in principle—flawless bits of perceptual information in the form of corpuscular transmissions emitted from or reflected by those objects or phenomena. In his earlier *Exercitationes*, by contrast, Gassendi did not think that we have a reliable knowledge of appearances, and cast doubts on our ability to establish either truth-criteria or belief-justification. Those doubts led him to suspend judgment about the nature and reality of objects. In the *Disquisitio*, Gassendi retains doubts about knowing essences but allows that we can know the reality of appearances:

. . . of a certain thing one may say that it is or appears in such a way, in the sense that it is endowed with such a mass, shape, movement, or position; and at the same time that it presents some analogy with respect to such and so organs [or] with respect to such and so animal or human being [or] with respect to such and so temperament or way of being, and other similar circumstances; but not that the thing would be for that [its appearance] such a thing in itself or its deep nature.<sup>8</sup>

That we can have an epistemic grasp of appearances, albeit with uncertainty, was accepted by many ancient Skeptics as well. What distinguishes Gassendi's view is the further claim—rooted in Epicurus' view—that those appearances somehow refer to objects in the world and that they are 'true' appearances.<sup>9</sup> He proposes, against the

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<sup>8</sup> *O III (DM)* 286b; *R* 70.

<sup>9</sup> Cf. also *O III (DM)* 286b; *R* 70. In chapter three, I examine Gassendi's notions of 'true' and 'truth-like', and how they may characterize appearances.

Skeptical view, that we can form justified beliefs about ‘actual’, or at least intersubjectively agreed-upon, phenomenal qualities of objects based on their appearances, though we have no grounds for knowing their essences. For the Skeptics, we cannot assent to “the honey tastes bitter” because we cannot know if honey has an essentially bitter taste; yet they allow that we can assent to the relativized claim “the honey tastes bitter to me.” Gassendi goes a step further, suggesting that we can assent to claims like “the honey has a contingently bitter taste” on the grounds that beliefs about appearances are at least in some cases acceptable on a broad intersubjective basis, in accordance with physiological norms of human perception. While we might not know the unchanging, essential qualities of objects, we do not *need* such knowledge to arrive at warranted beliefs about their inessential qualities. Two corollaries of this proposal, which I explore in Parts Two and Three, are the suggestions that science (in an anachronistic sense) can explain no more than apparent phenomena, and that such a delimited goal for science is satisfied by those accounts of material phenomena that are warranted by experiential data alone. The pressing question in this context, though, is how Gassendi departs from earlier Skepticist reservations and defends this more robust knowledge of appearances.

In sum, Gassendi suggests that we can have true and justified beliefs about not only appearances but the actual qualities we take those appearances to represent. The constituent claims of this view are that we base empirical knowledge—indeed, virtually all knowledge—primarily on information from the senses, which we attain directly *and* through the medium of signs, and that we can identify truth-criteria and means of justifying empirical beliefs. In the rest of this chapter and the next, I explore Gassendi’s grounds for the view that, as the font of perceptual information, the senses provide access to the primary source of knowledge. The further step of justifying empirical belief is explained by his account of knowledge acquisition—an account that I characterize in chapter three as a proto-realist theory of epistemic warrant. As we will see, Gassendi holds that such justification is possible altogether given a probabilist picture of empirical judgment.

*Knowledge is Based Primarily on Information from the Senses*

We find one clue to Gassendi's views on the perceptual source of empirical knowledge in the role he assigns the senses in his model of mental operations. According to this model the cognitive faculties include the senses, the imagination, and the understanding—much as in the traditional Scholastic model.<sup>10</sup> Against the rationalist strain in Scholastic thought, Gassendi suggests that the senses provide the most reliable data about the world, in virtue of passively receiving physical bits of information from the outside environment. By contrast, the other cognitive faculties are at least one step removed from the information acquisition process. The imagination, or *phantasia*, directs our will and contains images from imprinted 'species' or from sense-derived ideas combined in novel ways (for example, the image of an Hippocentaurus),<sup>11</sup> and the understanding, or *noûs* (*intellectus*), makes abstractions and generalizations and reflects on itself (its own past activity).<sup>12</sup> Moreover, we form universal claims with the understanding, by induction on particular images of the imagination.<sup>13</sup> Whereas the imagination and the intellect store and process the information which composes the content of beliefs, the senses constitute the primary tool in acquiring the information which contributes to our knowledge. This picture suggests that the foundational elements of empirical claims are bits of sensory information. Of course, just because the senses serve in this primary role does not guarantee that they are the true base of empirical knowledge; it still would be possible that we gain empirical beliefs indirectly through reason or directly through revelation.<sup>14</sup> But were Gassendi to hold such a view he would have to allow, as he does not, that the acquisition role of

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<sup>10</sup> The traditional Scholastic model of the cognitive faculties is rooted in Aristotle's *De Anima* 3.5, the ambiguities of which give rise to generations of debates over the perceptual roots of thought.

<sup>11</sup> *O* II 409b–410b.

<sup>12</sup> This requires powers of retention for, and contributes to our repository of, memory.

<sup>13</sup> *O* II 460a–b. The understanding also employs a correction mechanism, namely, the criterion of further sensory information; cf. discussion in chapter 3.

<sup>14</sup> For example, Descartes holds that reason provides basic principles that guide empirical beliefs. Mersenne, for his part, suggests that reason is the ultimate source of empirical beliefs; q.v. *La Vérité des Sciences Contre les Sceptiques ou Pyrrhoniens* (Paris: Toussaint du Bray, 1625), ed. and annot. Dominique Descotes (Paris: H. Champion, 2003), and James (1987).

the senses is an inefficient use of mental resources or that the senses function in a generally inadequate and unreliable fashion.

On the contrary, he argues that empirical knowledge is possible through the senses precisely because they are reliable. Moreover, he holds that we base nearly all knowledge on information from the senses—including knowledge of necessary truths like those of mathematics and logic,<sup>15</sup> and even knowledge of select religious truths including claims as to the existence of God. Thus practically the entire edifice of knowledge rests on the reliability of sensory information which, Gassendi claims, is largely independent of the cognitive contribution of reason and surpassed only by that of revelation. To establish that sensory information is reliable, his broadly Epicurean and anti-Skeptic strategy is to argue that we cannot possibly doubt two kinds of foundational sensory experiences: first, sensations of those particular things which appear to us (*tout court*), and second, sensations of those things appearing to us with such-and-so particular qualities. These sorts of information about appearances we perceive are likely to fail, Gassendi proposes, only if the senses themselves fail.

It might seem that this strategy is ill-founded because these cases cannot definitively establish the reliability of sensory information; even if we cannot doubt these fundamental sensations, there would be other kinds of sensations that should remain doubtful, for example, sensations of the particular qualities of things.<sup>16</sup> Thus the classical Skeptic's cases of round towers that appear square to us at close range or straight oars that appear bent in water (Sextus Empiricus, *Pyrrhoniae Hypotoses* I. 36–163) are presented as examples of sensations we could, if not *should*, doubt. Yet Gassendi proposes that we can doubt neither the sensation of the towers and oars appearing to us nor the sensation of their appearance to us, respectively, as round or bent: the only thing we might doubt is that we may properly gather from those sensations that the towers are indeed round or

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<sup>15</sup> *O* III (*DM*) 398a; *R* 484.

<sup>16</sup> Another potential difficulty here represents a standard complaint against externalism generally (and, in particular, a reliabilism such as Gassendi himself anticipates, in a manner): the senses could provide us with undoubtable information yet be unreliable. That is, we could be mistaken to rely upon such information simply because, for whatever contingent reasons, it was such that we happened to be incapable of doubting it. This difficulty is explored by Lawrence Bonjour; q.v. *The Structure of Empirical Knowledge* (Cambridge, Mass.: Harvard University Press, 1985).

that the oars are indeed bent.<sup>17</sup> But that, he contends (in Epicurean fashion<sup>18</sup>), is a matter of judgment made by the intellect, not by the senses. He further proposes that when we pull the oar out of the water and it appears straight, we not only cannot doubt our sensations of a quality of straightness (which in this instance is contingently associated with the oar), we also cannot doubt our sensations that the oar in particular is straight: “And when it would be permitted to doubt all the rest, at least we cannot doubt that such things appear to us, and it is not possible that it not be quite true that they appear to us in such a way.”<sup>19</sup> In short, we can form undoubtable beliefs about appearances where the perceptual basis of those beliefs fixes particular qualities to particular objects. This is a bit puzzling, however, for without any other background information in this instance we should only be sure of our sensations of the oar being straight in the same way (if not to the very same degree) we are sure of sensations of it being bent. Alternatively, we are more sure in one case or the other because something distinguishes the more reliable of our sensations, and in particular, relative to properties of those specific objects the qualities of which we sense. Yet there is no suggestion, at least in this context, as to any such distinguishing mark of reliability (such as would remove any doubts, for example, that the oar is straight rather than bent). Another difficulty is that Gassendi fails to tell us what exactly makes these two types of sensations foundational—that is, why they yield information which we value higher than that provided by other, competing sensations. On the other hand, it is a merit of his strategy that he addresses the Skeptic with the innovative proposal to license empirical beliefs by appealing to the indubitability of sensations of appearances *and* their accuracy, or what amounts to their resemblance to the truth.

Before looking at the details of this strategy, it bears stressing that this response to the Skeptic is intended to account for the viability of virtually *all* our knowledge, because Gassendi holds that what we typically take to be non-empirical knowledge is ultimately attained through the senses. Consider one of the hard cases, that we know the classic ‘truths of reason’—truths of mathematics and logic—by

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<sup>17</sup> *O* III (*DM*) 388a–b; *R* 532–34; *B* 266–68.

<sup>18</sup> Cf. chapter three. Only the intellect may err—the senses by their nature provide true information concerning appearances.

<sup>19</sup> *O* III (*DM*) 388b; *R* 534–35; *B* 267.



evidence from the senses. He suggests we arrive at exemplars of such truths not by reason, but by induction upon information gained from the senses. For example, every person learns about the ‘universal’ qualities of triangles, such as their number of sides, through inductive reasoning about all the triangles viewed in the past.<sup>20</sup> Likewise, he proposes, the proof of a claim such as “the whole is greater than the sum of its parts” is by enumeration. Only after we have gathered information from the senses concerning a class of particulars can we attribute characteristics to members of that class on a general basis. Thus we come to know such ‘truths of reason’ by drawing ‘universal’ claims from ‘empirical’ research regarding abstract objects like triangles, numbers, and propositions. Accordingly, we should eschew certainty and accept those claims tentatively, as they are no more secure than the results of similar previous or future empirical reports. One consequence is that we cannot hope to demonstrate universal qualities of mathematical or logical abstracta. That would entail drawing definitive, global conclusions from inductive arguments.<sup>21</sup>

This view faces some apparent objections. One difficulty is that truths of reason such as those concerning triangles are not dependent on past events. These truths should hold not only if, for example, triangles were never sensed, but even if triangles never existed. Thus Gassendi’s view would seem strange if we understood him to suggest that truths about triangles are dependent on sightings of triangles past. This difficulty dissolves, though, if we understand his proposal as the notion that knowledge of triangle-truths depends on *some* pertinent past observations, though not necessarily of extant triangles *per se*. Thus we might come to know such truths only if we have prior sensory experiences that yield relevant knowledge about triangles, whether past, present, or future. On this interpretation, his proposal suggests how we may attain such truths of reason (in geometry or mathematics. What remains to be specified—presumably a sizable task—is a normative account of the sorts of sensible data

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<sup>20</sup> *O* III (*DM*) 378b–79a; *R* 486–89; *B* 256–58.

<sup>21</sup> *O* III (*DM*) 375; *R* 470–73; *B* 246–47. Gassendi strongly anticipates Mill’s view. As for the second hard case—religious truths—Osler (1994) suggests that, for Gassendi, truths typically known through revelation are ultimately known on the basis of induction upon information from the senses. Yet Gassendi makes a special case of revealed knowledge, which he views as primarily known through divine presentation, Holy Scripture, and the writ of the Church; q.v. n. 25 below.

that, although not bearing content directly regarding such objects of knowledge, nonetheless furthers our understanding of their nature.

A related difficulty is that Gassendi's account ignores reasoned truths that are stipulated or conventional, rather than discovered or learned. Descartes anticipates this difficulty in his Fifth Meditation, pointing out that we do not ever need to encounter a triangle to come up with its essential features. Whether or not geometric features are essential in any interesting way, it remains the case that if, before we discover particular instances of  $x$ -figures we stipulate that they are those figures with  $y$  sides (containing  $y$  angles adding up to  $z$  degrees) then we can pick out the conforming shapes, and our knowledge of what an  $x$ -figure is precedes our having seen one. It is not clear how we are supposed to reconcile any such *a priori* knowledge of a stipulative truth of reason with Gassendi's claim that we require some empirical input.<sup>22</sup>

An additional potential obstacle to knowing truths of reason arises just in case attaining such knowledge requires consideration of those properties of a thing necessary to defining it—and which, consequently, may be taken to be its 'essential' properties. For example, that "prime numbers are divisible by themselves and 1 only" suggests that whatever would have such a property would be a prime number and any number without it would not be prime. For Gassendi, we should be able to acquire knowledge of such truths of reason by empirical means. But if such properties as referred to in those claims were *essential*, then—seemingly arbitrarily—Gassendi proposes that we would have no epistemic access to them. As with all properties of most concrete and abstract objects alike (spiritual objects being one exception) we might come to know about them only through the senses. Yet no such knowledge of essential properties is possible,

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<sup>22</sup> Such stipulative or conventional truths of reason are one class of the claims standardly considered as 'analytic' yet for Gassendi there are no analytic claims—save in theology and cosmology; q.v. Ralph Walker, "Gassendi and Skepticism", in *The Skeptical Tradition*, ed. Miles Burnyeat (Berkeley: University of California Press, 1983), 319–336. This suggests that Gassendi need not worry that such truths might be known *a priori*, unless he anticipates the suggestion that there could be a synthetic *a priori*. Since he considers no such possibility, his views on this matter are at least consistent. They cannot be correct, however, for independent of whether there are genuine analytic claims (or whether there is a synthetic *a priori*), there are apparently claims such as the ones Descartes considers which can be known by reason without the benefit of experience.

Gassendi holds, for the ‘intimate natures’ of things are impervious to the senses.<sup>23</sup> This constraint on our epistemic grasp of essences is clearly not absolute in his framework, for there are knowable essential properties even if such properties may not be known to be essential through experience. For example, we may know about the essential properties of God through revelation.<sup>24</sup> All the same, while Gassendi thinks it possible that material or abstract objects may have essential features, he will not allow that we may have epistemic access to those features, at least insofar as they are constitutive of an essence.<sup>25</sup> By failing to supply any distinction between essential and definitional features of things, and barring access to the former, it is difficult to make sense of his proposal to group the latter—such as he counts as traditional candidates for truths of reason—under the objects of empirical belief.<sup>26</sup>

Lastly, a broader concern is how, if empirical belief is grounded in the accuracy of the senses, perception may suffice for knowledge

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<sup>23</sup> Gassendi writes: “If one thing is an attribute or property and another thing the substance or nature of which it is part . . . just the same, knowing an attribute or property, for all that, is not knowing the substance itself or its nature. All that we can know is that this or that properties belong to such a substance or nature as this one, because that is apparent to observation and becomes evident by experience—and for all that one cannot penetrate to the level of the substance or the intimate nature of things.” *O III (DM)* 312b; *R* 186–189.

<sup>24</sup> As Osler notes (1994, 51), revelation has a inherited experiential character for Gassendi insofar as God revealed himself to biblical figures, whose testimony we continue to rely on (cf. *O I* 292b–293a; *O III (DM)* 326a–b, *R* 250–251). Yet revelation subsequent to those biblical manifestations is rather in the standard mode of divine presentation that results in our having faith-based ideas of God. Whereas the mastery of Creation is apparently an experiential source of our feeble notions of God, no such experiences can yield true ideas of God, who lies beyond our sensory grasp; cf. *O I* 295b–296a.

<sup>25</sup> Contrary to what Bloch (1971, 113–117, 131) and Osler (1994, 113) suggest (citing his nominalism of the *Exercitationes* (*O III* 159b–160b) and the *Disquisitio* (*O III* 374b, *R* 468–471)), Gassendi is not wholly anti-essentialist, even in the sphere of concrete objects. Notably, those assessments neglect essentialist aspects of Gassendi’s atomism; q.v. chapter nine.

<sup>26</sup> Curiously, the subsequent classic psychologist defense of the empirical nature of such truths of reason—John Stuart Mill’s *System of Logic, Ratiocinative and Inductive* (1843), in *Collected Works of John Stuart Mill*, ed. J.M. Robson (Toronto: University of Toronto Press, 1963–), volumes 7–8—shares Gassendi’s focus on geometry and arithmetic, though Mill’s reasoning is more carefully worked out. The classic holist discussion (q.v. W.V.O. Quine, “Two Dogmas of Empiricism”, *Philosophical Review* 60 (1951), 20–43; and for a rebuttal, Lawrence Bonjour, *In Defense of Pure Reason* (Cambridge: Cambridge University Press, 1998) ranges over more expansive mathematical terrains.

acquisition. Specifically, what about perception enables us to form viable and accurate empirical beliefs altogether? How can we account for the thoroughness of our range of beliefs given that perception itself provides only limited (or no) access to many objects of belief? Gassendi responds to the first question with a physicalist account: the information that constitutes the content of beliefs bears a physical form, and the cognitive processes of receiving and storing (and, in some cases, manipulating) information are physical processes. To supplement this knowledge acquisition story—and respond to the second question—Gassendi further maintains that we come to warranted beliefs about the world by taking perceptions to have surplus significance, beyond the representation of features of objects they directly and physically report. This is a consequence of his theory of signs (q.v. chapter two), which says that we arrive at some empirical beliefs on the basis of perceptions providing information about objects or phenomena we do not perceive.

*Physicalism about Perception and the Origin of Ideas*

The core of Gassendi's physicalist accounts of perception and empirical belief formation is an account of *visual* perception and beliefs founded on the same. The central claims here are that (1) an atomist matter theory underlies the physics of light and perceived images and the physiology of light and image perception, and (2) ideas are perceptual images, such that assigning an idea consists in physically perceiving an image. This account of perception is also a physicalist account of a first step in empirical belief formation, for sensory-based ideas are described at once as made of physical stuff and as the primary elements of empirical beliefs.<sup>27</sup>

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<sup>27</sup> One way this view could be wrong, accordingly, is if there is more to the initial steps of belief-formation than simply the reception of ideas. Along these lines, the Michaels argue that Gassendi's claim that 'idea' means no more than 'image' (see discussion below) has the consequence that, even though he may think sense-derived images are ideas, this does not commit him to taking sensory information as the ultimate source of beliefs in all cases; q.v. Emily Michael and Fred S. Michael, "Gassendi on Sensation and Reflection: A Non-Cartesian Dualism", *History of European Ideas* 9 (1988), 583–95. They suggest that in Gassendi's mental model the images or ideas we collect through perception are merely stored by the *phantasia*, until we form beliefs through a process of reflective judgment conducted by the higher-order and *non-physical* cognitive faculty of the understanding.

The starting point for Gassendi's account of the physiology of perception (including both physical analysis of the phenomena, and the structural analysis of ocular anatomy)—and in particular how we see light—is his atomist story of the physics of light and perceived images. He proposes that what we see generally (including light itself) is a function of how light is reflected off or transmitted by distant bodies. Light is composed of collections of atoms shaped in rays which travel from those distant bodies to our eyes, where those rays of atoms hit the backs of our retinas and are transformed into sensory data about either phenomena in our visual field (such as the character or behavior of bodies emitting or reflecting the light), or the light itself (such as its color or intensity).<sup>28</sup> This atomist account of light follows from Gassendi's global atomism, per his suggestion that light is understood as matter.

Not content to simply ground this light theory in his matter theory, Gassendi also offers a thought experiment in defense of the atomic composition of light. A ray of light passes through a dark room, entering through a hole on one side and exiting out a hole on the other side. Although the light passes through the room, it cannot be seen from the perspective of somebody actually in the room but outside the ray's path. This suggests to Gassendi that all there is to the ray is a set of light atoms traveling in a straight line from one hole to the other, such that, lacking physical contact with the observer in the room, the light passes directly through, undisturbed and also unseen. On the other hand, if light was not

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There is no question that Gassendi considers judgment to be the special province of the immaterial understanding, and so whatever claims or beliefs are subject to 'judgment' in his sense should be reasonably taken to be immaterial, too. But it is also clear that he views ideas from perception as providing the content of whatever claims or beliefs we arrive at concerning qualities we perceive and the objects that bear those qualities (see discussion below). This suggests that, whatever else we can say about the role of the understanding in Gassendi's mental model, the reception of ideas truly is the first step requisite for the formation of empirical beliefs.

<sup>28</sup> It is not unusual in early optics to run together discussion of the physical nature of light and the physiological sensation of light; q.v. David Lindberg, *Theories of Vision from Al-Kindi to Kepler* (Chicago: University of Chicago Press, 1976). Gassendi's account of the nature of light and its perception is detailed in the *Syntagma* (q.v. especially *O* I 422–432, *O* II 369–382), the letter to Mersenne of December 13, 1635 (*O* VI 81a–82b), and *De Apparente Magnitudine* (*O* III 420–477). Cf. Robert A. Hatch, "Coherence, Correspondence & Choice: Gassendi & Boulliau on Light and Vision", in *Actes du Colloque International Pierre Gassendi Digne-les-Bains, 18–21 Mai 1992* (*Annales de Haute-Provence* 321–322), Société Scientifique et Littéraire des Alpes de Haute-Provence (Digne: 1994), volume I, 365–385.

composed of matter in the form of atoms, it might well diffuse (and thereby be seen) though no obstacles are present in its path.<sup>29</sup> One promising aspect of this thought experiment is the proposal, consistent with his view that light is shaped into rays, that such rays could be focused with no divergent streams (well before the very idea of lasers!). Yet the experiment is flawed, for the observer would see the light ray passing through the room. Indeed, light from the ray must be diffuse, hence visible, since it is not passing through a vacuum. Even in a vacuum, though, nothing prevents such a ray from simply falling apart into distinct atoms, the likes of which we could observe.<sup>30</sup>

This flawed reasoning aside, the atomist accounts of light transmission and perception provide Gassendi with the basis of a physical account of perception generally. He takes it that, in addition to luminous bodies—which by definition can emit light—all material objects are capable of reflecting light atoms, which bear images representative of the reflecting or emitting objects. This is a materialist version of the Scholastic thesis that what we perceive are ‘simulacra’ or immaterial ‘intentional species’ of worldly objects.<sup>31</sup> The unit of perception, then, is a species or image composed of light atoms arranged in particular ways and transmitted by or reflected off the objects of perception. With this notion of a material, representative percept, Gassendi lays the groundwork for an account of perception as the reception of such material images by our sensory organs and the rendering of those images as suitable for scanning by whatever cognitive mechanism serves to read images. Indeed, he develops a perceptual theory along these lines, drawing additional support from optics-related observations he conducted with his longtime patron Nicholas-Claude Fabri de Peiresc in 1634, towards an understanding

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<sup>29</sup> *O* II 340a; q.v. Bloch (1971), 10.

<sup>30</sup> Gassendi’s matter theory could conceivably help him out in this regard, for he stipulates that atoms can be held together by hook-like protrusions (cf. chapter 9). But this is not an attribute that he assigns to light atoms in particular.

<sup>31</sup> *O* I 441b–449b. Bloch contrasts the scholastics’ notion of vision as an act of cognitively intuiting the immaterial contents of sensation with Gassendi’s notion of vision as a physical process, where the species are material representations through which we gain a mental image of the species-emitting object (1971, 20–21; *O* I 443a). On the Scholastic species theory, see Lindberg (1976) and Leendert Spruit, *Species Intelligibilis. From Perception to Knowledge. Volume II: Renaissance Controversies, Later Scholasticism, and the Elimination of the Intelligible Species in Modern Philosophy* (Leiden: Brill, 1995).

of the eye's structure and function.<sup>32</sup> These observations, largely an exercise in speculative morphology, consisted in dissection of eyes from a great many species, including birds, fish, and 'quadrupeds'. The two experimentalists concluded from their data that visual perception consists in reception of information about the external world in the form of physically-constituted images transmitted by external objects and collected at the retina. This suggestion lends support to Gassendi's proposal that we perceive the information borne by rays of light atoms, when those rays strike the back of our eyes.<sup>33</sup>

Specifically, Peiresc and Gassendi suggest rays of light atoms carry the material species—hence image-bearing information—across the crystalline humour. There, the rays are reflected against the retina and thus focused against the external, backside of the vitreous humour—where this information is turned into mental data. The convex crystalline humour in the front of the eye turns images carried by these rays upside down and the concave retina reverses them, so that when they hit the back of the vitreous humour we are able to visualize those inverted images, and thus the world, the right-side up.<sup>34</sup> Thus, Gassendi suggests, it must be that the cognitive act of

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<sup>32</sup> Brundell (1986, 89) suggests that Peiresc and Gassendi primarily set out to judge Kepler's proposal that an image appears on the retina; cf. Peiresc's letter to Dupuy of September 5, 1634 in Nicolas-Claude Fabri de Peiresc, *Lettres de Peiresc*, ed. Philippe Tamizey de Larroque (Paris: Imprimerie Nationale, 1893), Volume III, 97–101. Hatch (1995) and Joy (1987) alternatively propose that the optical explorations of Peiresc and Gassendi should be seen in the context of discussions with Boulliau, Naudé, and others, concerning the Poysson problem. Whatever the significance of such context, it is clear that Gassendi views these experiments, at least in retrospect, as of a piece with more general, wide-ranging naturalist pursuits, per his *Syntagma* discussion (q.v. *O* II 369 ff.).

<sup>33</sup> Gassendi saw this proposal as a challenge to the ancient view that vision occurs in the crystalline humour and to the contemporary view that it occurs in the retinal membrane; he and Peiresc proposed instead that it occurs in the rear of the vitreous humour (*O* V 315b; *VP* 225; Hatch (1995), 370–371).

<sup>34</sup> Gassendi and Peiresc concluded from observations of eye shapes in a wide variety of specimens that the back of the eye is always concave and therefore capable of righting an inverse image. Such an image would not be righted unless the back of the eye was also mirror-like, or else the inverse image might just diffuse straight through the retina. This mirror they claimed to have found in the form of a metallic-like buff on the surface of the choroid membrane.

Their account should be seen against the background of Kepler's account which, based on the recognition that light rays were all focused on the retina, further suggested that the image produced by the eye is inverted and must be reversed mentally; q.v. Johannes Kepler, *Ad Vitellionem Paralipomena, quibus Astronomiae pars Optica Traditur* (1604); Johannes Kepler, *Optics: Paralipomena to Witelo and the Optical Part of Astronomy*, trans. William H. Donahue (Santa Fe, NM: Green Lion Press, 2000). Hatch contrasts Kepler's working assumption that there are oblique rays of light

vision occurs *after* the rays pass through the center of the retina, such that our mental picture accurately reflects the way the world is:

... the faculty in question must reside in the center of this concavity, [the point] from which vision could gaze upon the reflected and righted image leaving the retina, and thus the object in its natural position.<sup>35</sup>

we perceive—hence must focus on the retina (per Lindberg, 1986, 207)—with Gassendi’s longtime assumption (apparently not operative in the *Syntagma*) that our eyes perceive only non-oblique, perpendicular rays (1995, 381–382). The suggestion is that Gassendi may have thereby made greater allowance for multiple points of inversion, and felt no particular need to insist on a single focal point.

<sup>35</sup> *O V* 315b; *IP* 225. While in his biography of his patron Gassendi attributes this optical picture solely to Peiresc (with reservations), their correspondence (and Gassendi’s correspondence with others) shows that the experiments and conclusions drawn were the result of a mutual effort; q.v. Hatch (1995).

Thus, in a letter to Elia Diodati of August 29, 1634, Gassendi writes: “I will content myself to tell you that generally we have discovered that the concavity of the eye, that is to say that which embraces the crystalline, aqueous, and vitreous humours, is a true concave mirror and, that alone representing the objects turned upside down, represents them in their natural position after having been turned upside down by the crystalline humour. Now that which is principally the effect of the mirror is the membrane we call *choroid*, or the posterior part of the uvea, which is commonly colored by the color that appears in the iris of the eye and a metallic polish having at its back a black sediment in the manner of a lead that one puts behind a mirror. And moreover being the rear concavity of the eye—apart from the place of the pupil, shaded in a similar blackness to ensure that the least glimmer entering the capacity of the eye is rendered there more brightly—this choroid is completely covered by the cloth or membrane that we call *retina*—which is such that, being conserved together with the choroid, seems one and the same in color, luster, and representation; indeed [the retina] represents things all the better because its surface is rendered vivid by the moistening it receives from the vitreous humour, which is more immediate to it than to the choroid. Thus it appears close to the truth of the matter that vision is produced in the retina because, moreover, proceeding from or being formed by, and being only a production and dilation of, the interior and soft part of the optic nerve, [the retina] receives, or if you like forms, in itself the eyesight, the expression of the animated image of the thing which to it is opposed.” (*MC IV* 335–341)

If their functional story is not accurate, at least their physiology of the eye was reasonably close to the mark (as diagram 1 illustrates).

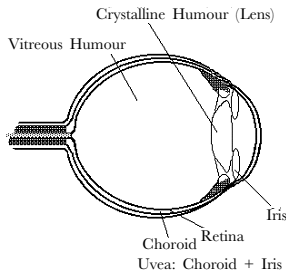


Diagram 1



It cannot be surprising that these gentlemen-scientists of Provence dissected a host of eyes and claimed to find the right apparatus for turning the material species into an image that the mind can retain. After all, they state *ex hypothesi* that the images we perceive, as well as our sensory and image-retaining organs, share a physical character. The striking aspect of this physicalist account is rather that Gassendi (and Peiresc) claim to begin with that the unit of perception is a physically-constituted image somehow borne by light corpuscles that are in turn carried by rays transmitted from or reflected by whatever object we perceive. Gassendi even reports experimental evidence for the representative nature of such images and for their preservation as representations through the optical process:

... Peiresc prodigiously exulted when, after extracting all the humours, and the crystalline having been next recovered and reestablished nearly in its place, he saw the image of the candle painted on the interior, on the retina, not in a reversed position but correctly; and otherwise, when the background was lit in a way that the crystalline could only receive light from it, it was established that the image, reversed through the retina, was righted on the crystalline that received it.<sup>36</sup>

We cannot place too much stock in these experimental reports, especially in light of Gassendi's errors, notably including the suggestion that images projected onto the retina are corrected for inversion. But such errors do not prevent him from attempting to account for a wide range of visual distortions and so address topics as diverse as microscopic and telescopic observations on one hand, and skeptical tropes regarding perceptual relativity on the other (cf. chapters 12 and 13, respectively).<sup>37</sup> The central point of this optics account, though, is that perception consists in the physiological reception of materially-constituted information that represents to us the external

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<sup>36</sup> *O V* 316a; *VP* 226. Here Gassendi describes differences between himself and Peiresc on the proper interpretation of these observations: the former locates the faculty of vision in the complex of optical membranes including the retina and holds that this faculty consists of the interior perception of images as transmitted from the external objects; the latter locates vision in the retina alone, and suggests it is the perception of external objects *per se*.

<sup>37</sup> Gassendi's principal, extended discussion of visual distortion is *De Apparente Magnitudine*, in which he accounts for visual distortion of the sun at the horizon and at its height at midday; recent discussions include Joy (1987) and Antonia LoLordo, "Flesh vs. Mind: A Study of the Debate between Descartes and Gassendi" (Ph.D. diss., Rutgers University, 2001).

world, and the representation of which is preserved in our cognitive reception process.

From this retinal image story it seems Gassendi takes material species to be straightforwardly representational. But later, in the *Syntagma*, he writes:

The species is not a picture . . . and is not itself looked at. It is simply the ground for knowing the object by which the species is impressed. In the same way the species impressed on the eye is not what is seen but is simply the ground for seeing the thing which emitted it.<sup>38</sup>

One way to understand this passage is as a reversal on Gassendi's part, taking the species as a non-representational stimulus which provokes the imagination into having the right image for the right external object, without the species itself presenting any image. A difficulty with this suggestion, apart from its interpretive plausibility, is that we might then wonder how, in the absence of any transmitted images, mental images are supposed to map onto the right external objects. There might be any number of plausible proposals to make here but Gassendi offers none—raising at least the possibility that such a non-representational view is not the perspective he intends.

Another reading, in any case, makes better sense of earlier claims about the representative character of species. In the quoted passage, Gassendi rules out not that material species have a representational character altogether but that they present us with pictures *per se*, presumably of external objects. It is possible to read him here as allowing that species present us with semblances of the *qualities* of external objects. This suggestion accommodates his denial that material species are pictures—yet captures his earlier proposal that we perceive likenesses of external objects. According to such a reading—still within representationalist bounds—we perceive an object's apparent qualities when species impress qualitative semblances upon our senses. Thus, we arrive at perceptual beliefs through our reception of the 'images' of material species which bear the qualities of their originating objects, and through our consequent grasp of the likeness of those objects from the qualities so transmitted.<sup>39</sup>

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<sup>38</sup> *O* II 405b (*SP*); trans. Brundell. 'Ground' here is *ratio*, and might be better translated as 'reason'.

<sup>39</sup> At any rate, there are two reasons to take the passage at *O* II 405b as something of an afterthought on Gassendi's part. For one, he simply asserts here without

One caveat regarding such a reading arises elsewhere in Gassendi's writings, in the form of a problem concerning our individual, subjective cognitions of qualities or 'qualia'. Even if we know how light excites the retina, he points out, we will not know the relationship between such stimulation and our cognizing particular phenomenal qualities such as colors, because we have no account that ties individual sensory qualia to the mechanical operations of vision.<sup>40</sup> The idea is that we do not receive, in our minds, sensations of the properties of objects directly—instead, we sense their representational corpuscular emissions in the form of material species. Hence we receive in perception representations of qualities *somehow* translated into qualia we associate with particular objects or their properties. Exactly how such a translation could occur is a mystery to Gassendi and, a different physicalist story notwithstanding, remains obscure by the lights of at least some contemporary philosophers of mind.<sup>41</sup> Though Gassendi appears to recognize the profundity of this problem, he does not view it as a principled obstacle to his perceptual theory, rather as a technical difficulty to be resolved. In sum, the material species account Gassendi provides leaves a number of difficulties outstanding, and much to interpretation, though some notion that vision entails the cognitive perception of images appears to be sustained in his view.

The second important element of Gassendi's account of perceptual belief, that getting an idea consists in getting an image, is proposed in the *Institutio Logica*<sup>42</sup> and spelled out in the *Disquisitio*. This is significant, we have seen, given Gassendi's view that perception is the reception of images of the external world and the proposal that ideas are just images. For barring any other primary source of empirical images, it follows that perception is the primary

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argument that species are not pictures. Further, as Brundell (*Pierre Gassendi*, 96) points out, Aquinas suggests that the species are no more than stimuli for provoking the right images (*Summa Theologiae* 1a q. 85 art. 2) hence Gassendi could have been motivated by doctrinal concerns alone to modify his view of species.

<sup>40</sup> *O* III (*AM*) 472a; q.v. Bloch, *La Philosophie de Gassendi*, 20, n. 54; (Bloch cites as well Carpentras ms. 1832, folio 244 v<sup>o</sup>).

<sup>41</sup> Recent discussions of the qualia problem include Frank Jackson, "Epiphenomenal Qualia", *Philosophical Quarterly* 32 (1982), 127–36; Daniel Dennett, "Quining Qualia", in *Consciousness in Contemporary Science*, ed. A.J. Marcel and E. Bisiach (Oxford: The Clarendon Press, 1988); and E.J. Lowe, *Subjects of Experience* (Cambridge: Cambridge University Press, 1996).

<sup>42</sup> *O* I 92a–b; *IL* 83–84.

source of empirical ideas. In the *Disquisitio*, he offers this reasoning in reply to what he takes (mistakenly) to be the cartesian view that whatever is an idea is a mental image. Gassendi argues that, in addition, whatever is a mental image is an idea. Moreover, he rejects Descartes's attributing to him the view that ideas are only images in the imagination. He insists rather that ideas are also images in the understanding, on the grounds that whatever ideas are in the understanding must be images.<sup>43</sup> Thus Gassendi believes himself and Descartes to agree on the claim that the objects of thought (our ideas) are mental images. An untidy consequence for Descartes, Gassendi maintains, is that this claim commits us to the material origin of at least some mental objects, a view that Descartes strenuously rejects.

Gassendi comes to this notion by embracing Descartes's (actual) view that whatever we form by thought—namely, ideas—are objects of thought, and what he takes to be Descartes's view, that such objects are given to thinking minds *qua* images, so that whatever ideas are given to minds just are images. Gassendi writes:

Now I ask you, that which we form by thought, whatever it is, is it not the object of thought? And the object in question, is it not juxtaposed with the thinking mind—and as given to it? And is that not presented and given under the aspect of some image that, if it is not fantasied [emerging first from the fantasy], is at least mental? And would not such an image be an idea? And reciprocally, would not the idea thus obtained be an image present to the mind? And yourself, as I have noted, have you not said that only the things thought as images are properly spoken of as ideas? If there are then among all the images some of them that I have not admitted to the set of ideas; if there are those that I have reduced to the imaginative fantasy; if there are those that I have not extended to the entire mind, or to all that we form by thought, then give the proof of it!<sup>44</sup>

Gassendi contends that Descartes runs into trouble here, for if ideas given to the mind are images, and at least one subset of these images

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<sup>43</sup> To claim that ideas in the imagination are images, Gassendi points out, does not preclude us from considering those or any other ideas that the understanding processes as images, too. He proposes that (i) all images, from the imagination or not, are mental items and thus objects of thought, so whatever images not from the imagination are still ideas (and so all images are ideas); and (ii) all ideas, from the imagination or not, are images present to the mind (thus all ideas are images); q.v. *O* III (*DM*) 333b–334a; *R* 282–285.

<sup>44</sup> *O* III (*DM*) 333b–334a; *R* 284.

are material—because we form them by perceiving material species—then any such idea or object of thought must be represented to the mind as a corporeal thing. But Descartes thinks all mental images are incorporeal.<sup>45</sup>

Gassendi does not face this putative problem because he does not think all our mental images are incorporeal: his perceptual theory suggests that we gain corporeal, imagistic objects of thought from sensory input. However, he faces a different kind of problem than the one he assigns to Descartes. How is it that the understanding, which Gassendi takes to be incorporeal, can process corporeal images? Naturally, it is open for him to suggest that we *also* form images in the understanding, which would perforce be incorporeal, but that would not explain how the corporeal images are handled. At any rate, it is *not* open for Gassendi to suggest that the understanding is the primary place for forming images with empirical content, because his perceptual theory says those images are introduced to our cognitive apparatus through sensory contact with the external world. This is indeed the core notion of Gassendi's account of empirical ideas: their physical character and derivation in perception highlights the thoroughly materialist origin and nature of those images or ideas that are the objects of beliefs about the external world. Yet for all the power and promise of this materialist account, Gassendi is not dogmatically committed to a belief framework where all the constituent ideas arise directly out of experience. Through use of the right sorts of inferences, the range of viable beliefs about the external world may be extended to claims only indirectly rooted in experience. This extension, through sign-based inference, is the story of the next chapter.

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<sup>45</sup> Gassendi further contends that Descartes is aware of this supposed difficulty yet insists anyway that we do not depend on material things (such as bodily sensations) for knowledge of immaterial things (notably, what Gassendi thinks of as cartesian mental images). Accordingly, Descartes is not entitled to 'representative' mental images of immaterial things (for example, angels) because the existence of such images would suggest that knowledge of those things comes from perceptual acquaintance with something material; q.v. *O* III (*DM*) 333b–334a; *R* 284. Now, Descartes does not think that all ideas are mental images, nor could he, for more or less the reasons Gassendi outlines. It is hard to see why Gassendi should have misinterpreted Descartes's position; perhaps he simply confused the latter's notion of idea-production (through pure thought) with his own notion of idea-production (through the gathering of images from experience).



## CHAPTER TWO

### THE THEORY OF SIGNS: CAUTIOUS LICENSE FOR TRUTH-LIKE EMPIRICAL BELIEF

The primary explanatory aim of Gassendi's theory of empirical knowledge is to account for our acquisition of ideas or beliefs about what is presented to us directly—the perceptually 'given'. It is not, however, his only explanatory goal. He further proposes that we attain beliefs about the external world through the senses *indirectly* with the aid of the inferential tools of 'signs': "... which, once it is known, leads us to the knowledge of something else."<sup>1</sup> Here Gassendi evokes an ancient view recommended, to varying degrees, by Aristotle and Epicurus—we employ signs as some form of evidence for claims otherwise not known, and as such, use them as a sort of inference tool for attaining conclusions about the nonevident. The Stoics, medical Empiricists, and Sceptics (including, prominently, Sextus Empiricus) accepted only a truncated version of this view, limiting the viable forms of signs and allowing a diminished inferential utility or none at all.<sup>2</sup> Against the Sceptic's dismissal of signs as tools for inferring

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<sup>1</sup> *O* I 80a; *B* 330.

<sup>2</sup> On the classical backdrop to Gassendi's theory of signs, q.v. James Allen, *Inference from Signs: Ancient Debates about the Nature of Evidence* (Oxford; New York: Oxford University Press, 2001). As Allen makes clear, the ancient debates revolved around the possible logical structures, underlying justification, and mental roles associated with signs and their use. Aristotle, for his part, sees signs as inferior to demonstrations in that the former may lend warrant to a claim but, unlike the latter, provide no explanation thereof. In his view, inference from signs yields the lowest form of warrant for claims that is still admissible, among the forms of non-conclusive argument that are nonetheless well-regarded (*Ibid.*, 8, 74–78; q.v. Aristotle, *PA* I 13, I 30). Sextus Empiricus distinguishes indicative and commemorative signification and dismisses the first form—which goes beyond the evident and is supposed to warrant claims regarding the hidden—as dogmatic. On the other hand, he accepts the second form—is supposed only to relate items from among the evident—as consistent with the sceptic's view (Allen (2001), 9, 106–122). Sextus borrows this distinction from the medical Empiricists, who rejected the logical inference picture of using signs altogether, suggesting instead that signs evoked associations already extant in the minds of those identifying and making use of the signs. In short, the only viable signs trigger memories of items previously associated with them. The Stoics, for their part, also upheld commemorative signification alone (contrary to Sextus's claim that dogmatists would wrongly embrace indicative signification) (*Ibid.*, 5–6, 9–10, 188).

claims about the hidden, Gassendi argues that information about what we perceive may bear additional significance regarding what we do not perceive, just in case we are aware of special conditions under which we perceive some phenomena where those conditions justify further beliefs about other phenomena not presented to us directly. The viability of this proposal thus rests, at least in part, on identifying those special conditions.

Following Sextus Empiricus, Gassendi divides phenomena into the manifest and the hidden, where the latter are non-evident in a number of possible respects: either totally (in-principle), temporarily, or naturally (contingently but indefinitely).<sup>3</sup> We can infer justified claims about the temporarily and naturally *non-evident* from the evidence of perceivable phenomena we take as signs indicating the character of the external world beyond appearances. Gassendi's primary justification for employing this kind of inferential tool, broadly speaking, is that nothing else accounts for the viability of a wide range of judgments we regularly make about the non-evident. Given that sensory information is the source of the constitutive ideas of empirical judgments, the intellect can only render judgments about things we do not directly perceive if it can interpret something we *can* perceive as evidence of the hidden.<sup>4</sup>

There are two plausible ways the perceived constitutes evidence of the unperceived, Gassendi proposes, adopting the classification of Sextus Empiricus (which Sextus also attributes to the Stoics). A *com-memorative* sign is evidence of the temporarily non-evident in the sense that it “. . . had always been observed to be connected with a thing

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The Epicurean view (developed, notably, in *De Signis* of Philodemus) was built around appeal to analogy—as in the notion that evident entity A behaving in manner M constitutes evidence that nonevident but analogous entity A' behaves in similar manner M'. The Epicureans wrestled with such questions as how claims about evident entities could be justifiably tied to claims about nonevident entities to begin with, and what the source of warrant could be for attributing degrees and sorts of similarity among putative analogues. Philodemus is particularly concerned to address the charge, probably issued by the Stoics, that similarity cannot produce true conditionals (and thus, deductively valid argument) (Allen (2001), 11–12).

Later thinkers, prominently including Augustine, continued to develop theories of sign-based inference, and such was a significant theme in Renaissance medical thought; q.v. Ian Maclean, *Logic, Signs, and Nature in the Renaissance: The Case of Learned Medicine* (Cambridge; New York: Cambridge University Press, 2002).

<sup>3</sup> O I 68b–69a; B 289–90. For Sextus Empiricus, q.v. *PH* 2.97–99; *Adv. Math.* 8. 145–148, 151, 156; and Allen (2001), 108–109.

<sup>4</sup> O I 81b; B 333.



which we could see clearly, so that as soon as we perceive it at a later date we are reminded of the thing which must accompany it.” Thus smoke is a commemorative sign of fire, lactation of pregnancy, and scars of wounds. In each case we judge from the evidence that the latter exist though we perceive only the former, because we infer as much from our prior grouping of co-temporal though distinct phenomena. By contrast, an *indicative* sign is evidence of the naturally non-evident in the sense that “. . . it is of such a nature that it could not exist unless the thing exists, and therefore whenever it exists, the thing also exists.”<sup>5</sup> Thus motion is an indicative sign of the void, sweat of pores, vital action of the soul, and the universe’s wondrous qualities of God the creator.<sup>6</sup> In each case we infer the presence of something we cannot see and perhaps never will, but which the need of a plausible explanation requires us to posit. If we could not refer to the signified thing, we should have no better way to explain the appearance of the indicative sign-phenomena. Here Gassendi recommends this explanation-guiding rule: if the best explanation of  $x$  is not possible without  $y$ , then posit  $y$ . As an instance of this rule, he proposes that before the age of microscopy there was no better account of how sweat appears on the skin’s outer surface than postulating pores in the skin. It is this explanation-guiding rule, and not any additional information (empirical or otherwise), that licenses our judgment that an unperceived thing exists just in case we perceive something else we take to be an indicative sign.<sup>7</sup>

<sup>5</sup> *O* I 81a–b; *B* 332.

<sup>6</sup> *O* I 81a–b; *B* 332–33. Both the pores and soul examples first appear in the Stoic discussion of signs, according to Sextus’ account; q.v. *PH* 2 and *Adv. Math.* 8.

<sup>7</sup> Gassendi recalls the suggestions in the *Prior Analytics* and in Stoic writings that signs should be classified as either necessary (*τεκμηρία* or ‘*tekmeria*’) or probable (*σημεία* or ‘*semeia*’); the distinction is also proposed by Epicurus (*Pyth.* 97), though Epicurus takes *semeia* to characterize conclusive and inconclusive evidence of the nonapparent. In the first case, Gassendi proposes, these perceived and unperceived phenomena are conjoined without known exception, hence we may take the former as indubitable evidence of the latter. In the second case, these perceived and unperceived phenomena are typically conjoined, hence we may take the former as reasonable or weighty, but not indubitable, evidence of the latter (*O* I 81a; *B* 331; here Gassendi is following Quintilian’s discussion [*Institutio Oratoria* V ix 3–5] of Aristotle’s view [*Rhetoric* I ii 1357b; *Prior Analytics* II 27]). According to the distinction between commemorative and indicative signs in *De Fine Logica* (in the *Syntagma*), we might think Gassendi sees commemorative signs as *tekmeria* and indicative signs as *semeia*. This is plausible enough but Gassendi does not himself draw this parallel, and he gives us no reason to suggest that inferences from commemorative signs have the force of necessity whereas those from indicative signs do not. Indeed, he

One reason to accept the evidence of indicative signs, Gassendi suggests, is the success of using such inferential tools. This success is demonstrated through the confirmation of prior inferences regarding data from instruments used to enhance our perception of the natural world. Advances in telescoping and microscopy have proven worthy various instances of reasoning from indicative signs. For example, it is possible to have reasoned that tiny insects such as mites have legs, before such legs actually could be seen, based on the indicative sign of their motion; now such reasoning would be vindicated by microscopic enhancement of the perceivable realm. Democritus, viewing the ‘filmy white’ nature of the distant light in the night sky, took this as an indicative sign that the sky contains innumerable many stars whose light forms an undifferentiated blur when seen from a great distance; his sign-based reasoning is vindicated by astronomical sightings through the telescope.<sup>8</sup> Of course, similar inferences could just as well have been made yet turned out to be false. One could have taken mites to have some other physiology for transport (slithery scales, for example), and Democritus could have reasoned that there is simply one single amorphous light source in the sky. Further, for every vindicated inference from indicative signs, there are surely many cases of proven failure, and still other cases of successful reasoning about the imperceptible by other means. However, Gassendi’s proposal is not that indicative sign-based reasoning is either sufficient or necessary to the task. It is rather that the success of those several instances we can point to means that indicative signs generally have demonstrative potential as an inferential tool for grasping what lies beyond experience.<sup>9</sup>

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suggests that indicative signs may be necessary in the sense that those phenomena we take as such signs only transpire if the hidden phenomena of which they are signs transpire as well. The notion that necessity should be linked to indubitability—as Aristotle and the Stoics believe of *tekmeria*—is not part of Gassendi’s view; as he does not think them any more impervious to doubt than any other empirical claims; q.v. chapter three.

<sup>8</sup> *O* I 82a; *B* 334–35.

<sup>9</sup> If the success rate was important here, as Gassendi seems to think, we might still cast aspersions upon reasoning from indicative signs if it turned out that the pattern of vindication was insignificant or random. Below, I explore his aspirations for exploiting inference from indicative signs in the experimental study of atmospheric pressure and his matter theory (chapters five and thirteen, respectively). Here I briefly note some of his attempts to identify viable instances of making such inferences in other scientific contexts:

Other worries persist, though, about this appeal to experiential confirmation. If vindication of such sign-based inference is contingent on subsequent experience, then what is vindicated is not the *sine qua non* reasoning underpinning indicative-sign based inference, but an *ex post facto* commemorative sign-based inference. While experience may show that our conjectures were confirmed and perhaps well-contrived, such a mark of approval would not demonstrate, endow, or rest upon any necessity relative to the initial indicative sign-based inference. This point highlights the epistemic character of the operative modal claim: what makes for *sine qua non* conditions in indicative sign-based inference is that we know of some  $x$  only because some  $y$  exists, quite apart from any putative necessity we attribute to the existence of  $y$  (as considered without regard to  $x$ ). This last point in turn makes clear that the difference between the forms of sign-based inference (commemorative versus indicative) turns on the

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- i. *The void.* Following Epicurus, Gassendi suggests we can infer from the motion of particles of matter that void exists between those particles. Without void, there could be no material motion, since a voidless world constitutes a plenum where all matter is locked into its original position, as a “single totally rigid mass, utterly inflexible . . . with all its places occupied in every direction, so there would be nothing that could yield its place into which something else could succeed it.” Thus motion is an indicative sign of the void, via the notion that such succession of place is possible. (*O I 83a; B 338*)
  - ii. *Astronomy.* Gassendi cites four instances of sign-based inference: (a) We take the changes of lunar quarters as a sign of the moon’s spherical shape. Without such a shape the moon would not reflect the light of the sun in its quarterly pattern—given such a shape, that pattern must result. (b) We infer from lunar states at times of eclipse that eclipses are caused by the positioning of heavenly bodies in the path of the sun’s light. The only lunar eclipses occur at full moon, when Earth blocks the sun’s light projected in the moon’s direction; and the only solar eclipses occur in a new moon, when the moon blocks the sun’s light projected in the direction of Earth. (c) We infer from the appearance of Venus (as a horn and larger in retrograde motion, and as full and smaller in forward motion) that Venus is either beyond the sun or between the Earth and the sun. (d) Copernicus inferred that the Earth moves from the apparent growth Mars undergoes when moving away from the sun and from its apparent shrinking when moving towards the sun; he reasoned that we could only see Mars as larger in this case if we were approaching it, and as smaller in this case if we were moving away from it (namely, on the opposite side of the sun). (*O I 83a–b; B 339*)
  - iii. *Geometry.* The truths of geometry are not self-evident in that we require a proof before we assent to such claims as “the volume of a cone is one-third that of the cylinder”. We prove their truth by inferences from axioms: “. . . the definitions by which a point is said to have no parts, a line is length without width, a surface is width without depth”. Gassendi somehow construes such axioms as signs (*O I 83b–84a; B 339–40*), though it is not clear what he takes them to be signs of.

current state of our epistemic grasp of objects for which we have signs, rather than any underlying metaphysical features of those objects.<sup>10</sup> This suggests that the core defense of such sign-based inference should appeal to aspects of epistemic states of affairs.

Indeed, Gassendi bases his principal defense of sign-based inference on the strategy that such inferences are viable if two epistemic conditions are fulfilled, that they are satisfactory to reasonable persons and—what he takes to be an equivalent condition—undeniable on pain of contradiction.<sup>11</sup> His primary interest here lies in the second condition. Thus, for example, in considering the inference to the existence of pores in the skin from the sign of sweat, he proposes that it is evident from such signs that there must be pores for if there were not, we would be lead into a contradiction: “. . . two bodies would have to be in the same place at the same time.” Rejecting this last claim as a contradiction, together with the available evidence of sweat upon the skin, yields the claim that there are pores, the truth of which we can be certain. Our certainty of the truth of such claims is provided by our rejection of any claims to the contrary as contradictory.<sup>12</sup> The first condition—that a claim is satisfactory to reasonable persons—is sufficiently less interesting to Gassendi that he does not spell out how it is fulfilled in this instance. Yet his suggestion is clear enough: we take phenomena such as sweat appearing on skin as signs that permit such inferences, in order to

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<sup>10</sup> Q.v. LoLordo (2001), 226.

<sup>11</sup> Gassendi also pursues this strategy relative to accounts of some basic epistemic notions, including his view of truth; q.v. chapter three.

<sup>12</sup> Gassendi’s argument is as follows:

given A, B, and  $\neg A \ \& \ B \supset C$ , where

A: it is possible for two bodies to be in the same place at the same time,

B: skin has sweat on it, and

C: skin has pores,

and if we can show  $A \vdash \perp$ ,

then C

Gassendi is not content to take this as an ordinary demonstration of C, perhaps because he views demonstration as a generally less-than-certain affair (q.v. chapter three). Instead, he imputes certainty to our knowledge of C as a result of this argument, on the grounds that A is shown to generate a contradiction. It is hard to see why reasoning from a contradiction should yield any additional epistemic quality (such as certainty) above and beyond what is provided by other, similar reasoning without reference to contradiction. This is especially problematic given that any special certainty generated by A yielding contradiction is not obviously transferable to any other premise or to the conclusion C. Indeed, one may doubt that for Gassendi we would be likely to attain certainty of B given its direct basis in sensory data.

generally explain the assuredness of reasonable persons about the non-evident on the basis of ideas about the evident. Accordingly, sign-based inferences are acceptable, not only because they allow us to avoid unpalatable claims, but also because they thereby conform with the thinking of persons who reason well.<sup>13</sup>

Beyond the psychic comfort or rhetorical power of agreement with reasonable persons, Gassendi is highlighting the value of testimony—often considered the early modern era as empirical data<sup>14</sup>—in the form of right reasoning presented by those so cognitively equipped. There is a hint of reliabilism here: we have warrant for beliefs if we employ such inferences to those beliefs as reasonable persons accept. What accounts for the proposed warrant is, perforce, the *dependability* of successful inferential performances by reasonable persons. As with a full-fledged reliabilism, this localized warrant for inferences from signs is subject to the difficulty that a high standard of cognitive performance does not guarantee conformity of reasoning, much less convergence on the beliefs most likely to be true. Thus sign-based inferences cannot be said to produce results satisfying reasonable persons just in case such persons widely disagree about the merits of any such inferences in question.

The second condition, too, is not without difficulties. One problem, as regards the particular case Gassendi cites, is that it is physically absurd but not a logical contradiction to believe that two bodies are in the same place at the same time.<sup>15</sup> Why does Gassendi think descriptions of physically impossible events are contradictory? In the *Institutio Logica* (of the *Syntagma*) he elevates some principles of physical science to the status of necessary or indubitable; perhaps he mistakenly infers from this that whatever contradicts the indubitable is in itself contradictory. Whatever the inference, though, it is reasonable to suggest that Gassendi is motivated to accept indicative signs (and their corresponding inferences) on these grounds by the need to avoid physically absurd claims.

A second, rather different problem, proposed by Ralph Walker, results from taking sign-based inferences to be warranted if *self-evident*, which view is said to follow from Gassendi's appeal to a principle

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<sup>13</sup> O I 85b–86a; B 346–47.

<sup>14</sup> Cf. Richard W. Serjeantson, "Testimony and Proof in Early-Modern England", *Studies in History and Philosophy of Science* 30A (1999), 195–236.

<sup>15</sup> Thanks to Mark Kulstad for this point.

of non-contradiction. Walker contends that any such justification by self-evidence may be undermined by the general form of Gassendi's own argument against cartesian grounds for epistemic warrant.<sup>16</sup> Gassendi famously argues that Descartes' clarity and distinctness warrant for knowledge is inevitably based on premises we only can claim to know because they are themselves clear and distinct. Similarly, Walker suggests, to argue that inferences are permissible if and only if self-evident requires premises we can accept only because they are self-evident.<sup>17</sup> Further, even if we could surmount this last difficulty, Gassendi provides a cognitive model that seems to severely limit the warrant for such inferences. For although he says in the *Institutio Logica* that the intellect or understanding cannot reject self-evident premises,<sup>18</sup> in the *Disquisitio* he states that we have no reason to place absolute trust in intellectual judgments, apparently undercutting the viability of the understanding as a mechanism which consistently grants warrant to the self-evident.<sup>19</sup>

While there may be many problems with locating the warrant for beliefs in appeals to their self-evidence,<sup>20</sup> this particular line of criticism misconstrues the guideline Gassendi urges for proper inference from indicative signs. While we license such an inference when alternative accounts of the sign-phenomena constitute or generate physically impossible claims, it does not follow from this that the successful inference wins its warrant because it is self-evident. Indeed, it could be perfectly nonevident, prior to attaining the relevant empirical data, that a given account of sign phenomena yields a physically impossible claim (rendering the account false). As we have seen, a charitable understanding of Gassendi's view is that inferences from signs bear the warrant of empirically-informed reasoning regarding

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<sup>16</sup> Ralph Walker, "Gassendi and Skepticism", in *The Skeptical Tradition*, ed. Miles Burnyeat (Berkeley: University of California Press, 1983), 328.

<sup>17</sup> *Ibid.*, 328.

<sup>18</sup> *O* I 85b; *B* 347.

<sup>19</sup> *O* III (*DM*) 280a; *B* 167.

<sup>20</sup> The problems outlined here may not be insurmountable. It is not obvious, for example, that we could *not* defend the self-evidence standard on self-evident premises, since the nature of the standard for admitting these higher-order inferences need not have anything to do with the nature of the lower-order premises in question—unless the argument for that standard relied on inferences of the same kind. But in that case there would be a circularity difficulty whether the premises were self-evident or not.

the physically possible—quite apart from any self-evidentiary nature they may feature.

A further, grander problem, Walker suggests, plagues Gassendi's defense of sign-based inference insofar as he appeals to the role of reason in trying to license, against better empiricist principles, inferences that go beyond the perceptually given.<sup>21</sup> It is curious enough that a strict empiricist like Gassendi appeals to experience to justify beliefs based on inferences *beyond* experience.<sup>22</sup> Worse still, his proposed means of justifying sign-based inference entails that the *understanding* accepts such inferences, on pain of contradiction. Hence the warrant for beliefs so inferred appeals to something outside experience altogether, namely, the reasoned judgment of the immaterial understanding—which itself is opaque to empirical study. Walker contrasts Gassendi's thinking in this sphere with the Quinean notion that we should not bother trying to find *a priori* grounds for justifying beliefs about inferences beyond experience. Instead, we should naturalize epistemology and describe the ways we actually and normally come to maintain such beliefs. If by the lights of this approach we can still talk of right and wrong inferences, the mark of aptness lies in their empirically testable consequences. The naturalizing epistemologist answers the skeptic's demand for justificatory grounds by providing descriptive, non-normative accounts of epistemic warrant. Thus, for example, some *x* knows that *p* on the grounds that some *y* knows that *p*, *y* told *x* 'p', and *x* believes *y*; or *x* read 'p' in a book; or *x* observed that *p*; and so forth.

In brief, Walker's objection is that Gassendi's empiricism should block his appeal to right reasoning as warrant for empirical beliefs because the relevant reasons (and background cognitive account) are at root not empirically derived or, if so derived, not empirically endorsed. However, Gassendi has an empiricist story to tell about how such guarantees are provided. When he says we justify sign-based inferences just in case they are, among other things, "obvious to all rational men",<sup>23</sup> he appeals to the empirical claim that those inferences are justified for the reason that they are evident—because indubitable—to a plurality of rational thinkers. Indeed, this is a kind of proposal plausibly made by a naturalizing epistemologist.

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<sup>21</sup> Walker (1983), 329.

<sup>22</sup> *Ibid.*, 331.

<sup>23</sup> *Ibid.*, 333.

In another anticipation of a modern, naturalized theory of knowledge, Gassendi's appeal to judgment of the intellect, in defense of sign-based inference, yields *a posteriori* knowledge of the warrant for beliefs we so infer. We locate this warrant (as well as viable truth-criteria, he suggests) through detection of our cognitive capacities—and not by reflection on the nature of justificatory norms as Descartes, for example, pursues with respect to clarity and distinctness. This is, of course, hardly the stuff of mature empirical psychology, the ostensible route of the contemporary naturalizing epistemologist. But it is a crude, semi-speculative kind of cognitive psychology, crucially supported in this case by Gassendi's contention that the acceptable kinds of sign-based inferential beliefs are the ones not doubtable under normal circumstances by the average rational person. On this reading, there is no inconsistency between Gassendi's empiricist proposal that there is no *a priori* knowledge (outside of revealed truths) and his suggestion that the justification of beliefs may consist in reasons determined by the understanding, in accordance with his views on cognition. In this respect Gassendi approaches the Quinean position that we can defend beliefs derived from inferences beyond experience through appeal to experience just in case the defense is descriptive in nature.

In the end, Gassendi is very much aware that the indicative signs account must establish empirical grounds for warranting inference from such signs. Towards this goal, he addresses the skeptical charge that there are no criteria by which we could recognize phenomena as signs yielding justified veridical judgments about the non-evident. Thus, Sextus argues that we cannot even hope to discover a criterion for judging claims about the naturally non-evident since we never experience such phenomena and it is therefore unintelligible by the standard that “every intelligible thing derives its origin and source of confirmation from sensation.”<sup>24</sup> Gassendi counters that we recognize sign phenomena themselves—since they are evident—by the criterion of the senses or test of experience. Further, we can reason from such signs to the non-evident just in case our reasoned

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<sup>24</sup> *SE* II 429. The original Stoic proposal, Sextus suggests, is that appearances may function as indicative signs if they are sufficiently ‘apprehensive and gripping’. Sextus argues to the contrary that these characteristics yield neither regularity nor viable existence claims. Gassendi's response, then, is something of an attempt to flesh out the Stoic view.



judgments meet the criterion of the intellect, that is, rational constraints on our thinking—including, principally, the constraint that we accept incontrovertible claims. In sum, indicative signs give us evidence of the imperceptible and the basis for warranted claims about the same if we can (a) form empirically viable beliefs about the sign-phenomena and (b) accept only those claims about the hidden that are incontrovertible—in particular, judgments that given signs could not be present unless some indicated imperceptible were, too.<sup>25</sup> The force of this reply to the Sceptics's worries about criteria lies in Gassendi's proposal that such criteria can be identified as allow judging the veridical nature of claims about the nonevident. His defense of this proposal—ultimately, an appeal to the reliability of cognitive faculties processing sensory data—is the topic of the next chapter.

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<sup>25</sup> *O* I 81b; *B* 333.



## CHAPTER THREE

### EMPIRICIST EPISTEMIC WARRANT, AND PROBABILIST AND ANTI-ESSENTIALIST CONSEQUENCES

#### *Epicurean Truth-Criteria and the Justification of Empirical Belief*

Following classic Epicurean form, Gassendi proposes to reject classic Skepticism concerning beliefs about appearances by establishing that such beliefs are generally acceptable because true—or at least truth-resembling.<sup>1</sup> This picture of the historical conflict is not wholly accurate, given that the Pyrrhonians actually accept beliefs about the evident—though their acceptance is provisional, without any attempt at justification and lacking any admission of truth or its likeness.<sup>2</sup> As Gassendi would have it, however, accepting some degree of accuracy among appearance-beliefs entails a means of gauging their truth-likeness such that—*contra* the archetypical Skepticist view—there must be at least one epistemic criterion. But Gassendi goes further still, suggesting that the same source of this criterion also yields grounds

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<sup>1</sup> O I 80b; B 329. The Epicurean view that all beliefs about appearances are true has its origins in Epicurus' notion that presentations to the mind cannot be false (*Her* 50–51). While traditionally conceived of as a response to the Skeptics, this is technically an anachronism. The widely divergent commentary on the truth of appearance beliefs includes Cyril Bailey, *The Greek Atomists and Epicurus* (Oxford, The Clarendon Press, 1928), 254–257; David J. Furley, “Knowledge of Atoms and Void in Epicureanism”, in *Cosmic Problems: Essays on Greek and Roman Philosophy of Nature*, David J. Furley (Cambridge; New York: Cambridge University Press, 1966/1989), 161–171; Stephen Everson, “Epicurus on the Truth of the Senses”, in *Epistemology (Companions to Ancient Thought 1)*, ed. Stephen Everson (Cambridge; New York: Cambridge University Press, 1990), 161–183; Gisela Striker “Epicurus on the Truth of Sense Impressions”, in *Essays on Hellenistic Epistemology and Ethics*, ed. Gisela Striker (Cambridge; New York: Cambridge University Press, 1996), 77–91; and Elizabeth Asmis, *Epicurus' Philosophy of Science* (Ithaca; London: Cornell University Press, 1984), esp. 141–144. I discuss this further in note 40, below.

<sup>2</sup> The Pyrrhonian allowance for belief regarding the apparent or evident makes no concession to belief regarding the nonevident. This move proscribes the possibility of underlying explanations of the evident, which the Pyrrhonians write off in any case when they counsel suspending judgment instead of adjudicating between conflicting appearances; cf. *DL* IX 105 ff.

for justifying judgments about such appearance-beliefs.<sup>3</sup> He proposes, in short, that the reliability of the faculties of sensation provides warrant for empirical claims.

It may seem puzzling, at least from a historical perspective, for Gassendi to intend his criteria as a means of gauging justified belief as well as of truth. Among the Stoics and Epicureans, epistemic criteria are supposed to constitute standards of the truth of propositions—and by extension, the sensory impressions that lend content to propositions.<sup>4</sup> In late twentieth century epistemology, by contrast, such criteria are intended rather as standards for justified belief.<sup>5</sup> Can the same criterion serve both as a mark of truth and that which provides warrant for beliefs? One reason this seems unlikely is that, if there are true beliefs we could hold accidentally, they would lack warrant by whatever criterion we identify. Even without this concern, however, Gassendi should be generally wary of conflating truth and epistemic warrant, as he takes Descartes to task for doing just that in a different context. Thus, Gassendi suggests Descartes is wrong to think of his criterion as a means of judging not only the *truth* of mathematical beliefs, but their *certainty* as well:

... I have judged otherwise that it is impossible to pass from a smaller quantity to a lesser quantity, without passing through their equality—just as two lines approach each other more and more nonetheless without meeting if we prolong them indefinitely. It seems to me in effect

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<sup>3</sup> Gassendi's conflation of truth-criterion and justificatory standards is perfectly consonant with the classic Epicurean account. His principal innovation, we will see, is to support his account by appeal to empirical evidence—and thereby provide a putative means of detecting the 'primitive' truth of sensory impressions.

<sup>4</sup> Q.v. Gisela Striker, "The Problem of the Criterion", in Everson (1990), 144–145; and Asmis (1984), 86–95. As Striker notes, Plato and Aristotle, along with the Epicureans (on some occasions; q.v. *Her* 38), interpreted the cognitive faculties of reason and the senses as 'criteria' for their role as instruments of epistemic judgment, whereas the Stoics and Epicureans (on other occasions; q.v. *DL* X 31) understood 'criteria' rather as cognitive content—impressions from the senses and fundamental concepts—that would serve as standards for epistemic judgment. What we see in Gassendi is an understanding of 'criteria' that runs together the two Epicurean notions, taking the cognitive faculty of the senses as providing a standard, rather than an instrument *per se*, for epistemic judgment.

<sup>5</sup> In contemporary literature, the debate revolves around whether the Skeptic is best defeated by first identifying particular instances of justified belief (thence a criterion) or by first identifying a criterion (thence particular instances). The *locus classicus* is Roderick M. Chisholm, *Theory of Knowledge* (Englewood Cliffs, NJ: Prentice-Hall, 1966/1977/1989); cf. as well his *The Foundations of Knowing* (Brighton: The Harvester Press, 1982) and Mathias Steup, "Problem of the Criterion", in *A Companion to Epistemology*, ed. Jonathan Dancy & Ernest Sosa (Oxford: Blackwell, 1992), 378–381.

that to perceive these things clearly and distinctly, I would consider them as very true and indubitable axioms; later on, however, arguments would be found to persuade me of the contrary as a thing more clearly and distinctly conceived. Even at present I hesitate still when I consider the nature of mathematical hypotheses. That is why it is permitted to say that it is true that I know such and so propositions insofar as I suppose or conceive such manner of acting for quantity, lines, and similar things; but that these so many propositions be true in themselves, that is something we cannot affirm with certitude.<sup>6</sup>

Gassendi does not heed his own advice, though, for his approach to the problem of the criterion also conflates, or at least combines, these two elements of knowledge. In brief, he proposes that there are criteria by which we can detect, with great regularity and dependability—in short, with reliability—that appearances and claims about appearances bear something very near the mark of truth. Further, he suggests, this reliability in turn provides just the warrant we need to reasonably sustain veridical beliefs about the world.

A first step in understanding Gassendi's view is grasping his attempt to define truth as a property the bearers of which may fall outside traditional bounds of beliefs, propositions, or judgments. In the *Institutio Logica* he suggests that a truth-property is applicable to three kinds of items: objects in the world, concepts or ideas of such objects, and—per the standard, modern view—propositions we form about the same.<sup>7</sup> Object-truth, which he calls “truth of essence or existence”,

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<sup>6</sup> *O* III (*DM*) 314b–15a; *R* 198–200.

<sup>7</sup> Further, Gassendi follows the Epicurean view that all sensory perceptions are true, which might be thought to yield yet another form of truth. Indeed, a number of commentators suggest that the Epicurean view yields a sort of ‘perceptual truth’; for this standard interpretation, q.v. John M. Rist, *Epicurus, An Introduction* (Cambridge: Cambridge University Press, 1972), 19 ff; A.A. Long, *Hellenistic Philosophy. Stoics, Epicureans, Sceptics* (London: Duckworth; New York: Scribner's, 1974), 106; Striker (1977), 133–135; and Everson (1990), 165. An alternate hypothesis is that Epicurus understands perceptions as ‘existent’ or ‘real’, for *alēthēs* (ἀληθές) can be understood in this way, and not only as ‘true’, though as Everson notes, this interpretation saddles Epicurus with the trivial view that perceptions (and feelings, which are also *alēthēs*) are real (165–166). Everson defends the standard view on the basis of the claim by Sextus (*Adv M* VII 205, VIII 63) that perceptions are true where they are caused by a real external object and accord with, or resemble, the object. (Everson's specific proposal is that such resemblance consists in property identity between the perception and the object (1990, 167–169).) While Gassendi does not weigh in on this issue directly, his notion of object-truth, parsed as ‘true to the underlying reality’, would accommodate characterizations of sensory perceptions as true in a manner consonant with the standard interpretation of the Epicurean view.

consists in that feature—which he believes may be found in all things—of having a particular identity, such that it is “exactly what it is and nothing else”. Since all existing things, including copies and false versions of other things, necessarily have this property,<sup>8</sup> there is no sense in which we can talk about a corresponding object-falsity.<sup>9</sup> For example, the book in my hand is a true book because it exists, and the book I have seen depicted in a painting is a true book representation because the representation exists (though not necessarily the book represented). By contrast, the book in my thought “I would like to read a book” presumably bears no object-truth value in this context since there is no particular existent about which I am thinking. Object-truth is only applicable, then, if the object in question is identifiable as a specific entity which exists, whether as concrete or abstract.

Concept-truth or idea-truth, by contrast, is defined as follows: a concept is true if and only if the concept agrees with its subject (what the concept is predicated of) and false if and only if it disagrees with its subject.<sup>10</sup> By ‘agreement’ between two such things as concepts and their subjects, Gassendi means that there is a property-wise correspondence between them, where the one is neither contrary to the other (as black from white) nor, if a matter of degree, overly disparate from the other (as one genus from another).<sup>11</sup> Hence ideas are true if they and their subjects enjoy some such regular correspondence. An even more basic requirement for concept or idea-truth, then, is that the concepts or ideas are sufficiently complex as to have a subject-predicate structure, otherwise there is no place to find the requisite correspondence. Accordingly, an idea of a given table is true if the ideas of tables (*simpliciter*) and the particular

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<sup>8</sup> “. . . whatever exists in reality . . . is true and may be called a truth of existence” (*O* I 67b–68a; *B* 286). Gassendi is referring to Aristotle (*Metaphysics* II i 993b) in this passage but is specifically following Aquinas in recommending that truth may be predicated of not only propositions but of objects and concepts as well—or rather of the relations of those things to the mind. In particular, truth may consist in the conformity of a thing to an intellect: “. . . a house is said to be true that expresses the likeness of the form in the architect’s mind; and words are said to be true so far as they are the signs of truth in the intellect.” Q.v. *Summa Theologica*, 1a, q. 16 art. 1.

<sup>9</sup> *O* I 101a; *IL* II § I, 105–6.

<sup>10</sup> *O* I 100b–101a; *IL* II § I, 105.

<sup>11</sup> *O* I 101a–b; *IL* II § II–IV, 106–107; on genus-species relations, q.v. *O* I 98b–99a; *IL* I § XVII, 99–100.

features of the table in question—for example, being blue—correspond to no contrary or overly disparate attributes. The idea of a blue table can be true, then, because there is nothing contrary about the attributes of being blue and being a table—and so, nothing contrary about the more general table-idea and the more specific table-being-blue idea. A ‘table’ idea is false, however, if it says tables are made out of courage—for tables and courage fall under entirely disparate genera, such that they bear no property-wise correspondence. On the other hand, a ‘table’ idea can be true even when the properties in question are rather disparate, so long as there is but a minimal generic commonality. The idea of tables made out of ice can be true because tables and ice fall under the same genus, material solids.<sup>12</sup>

Gassendi does not wholeheartedly embrace this view. He cautions that we might not have a way of judging a given concept as true or false unless we have an accompanying pronouncement that the thing represented by the concept is (or is not) as represented by the concept.<sup>13</sup> His worry seems to be that concepts *per se* may be formed with abandon, whereas attaching a truth property is a more rigorous enterprise, requiring that we enunciate the concepts in written or spoken form. In this manner, it may be detected whether those concepts agree with their referents. He does not specify why such enunciation is required to determine that agreement. One might suppose that, in the absence of pronouncing a particular concept, there

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<sup>12</sup> A notion akin to Gassendist concept-truth underlies Descartes’ views (in the *Meditations*) on the material falsity of ideas. Descartes proposes that ideas (of sensations, in particular) are materially false if what they represent—following the Latin, ‘... an non rerum’, is not a thing, or—following the French, ‘des êtres chimériques qui ne peuvent exister’, is something that does not exist (for the view that the French phrasing best expresses Descartes’ perspective, q.v. Richard Field, “Descartes on the Material Falsity of Ideas”, *The Philosophical Review* 102 (1993) 3, 309–333). Descartes, like Gassendi, distinguishes such a sense of truth from that ranging over propositions (‘judgments’). What makes judgments false is the failure of propositional content (which takes the form of ideas) to represent correctly, or to agree with what the judgment refers to. What makes ideas false is the failure of such ideas, in and of themselves, to represent correctly, and this occurs when they represent something non-existent as an existing thing (cf. *AT* VII 43; *CSM* 2: 30; Field (1993), 314). Given that the latter sort of failure can engender the former sort (*AT* VII 231; *CSM* 2:162), propositional truth turns out to be a partial function of ideational truth.

<sup>13</sup> “... exspectaturque, donec pronuncietur rem talem esse, aut non esse...” *O* I 100b–101a; *II* II § I, 105.

would be no experiential checks on what the concept might be thought to represent, yielding all manner of subjects that are not only not actual but not even possible. By pronouncing concepts, we ostensibly limit ourselves to enunciating the possible, which should allow for better (or, at least, simpler) judgment as to whether those concepts are true or not. However, at such point (as Gassendi notes), we are articulating propositions and not merely conjuring concepts.<sup>14</sup> The relevant notion of veridical character, then, is apparently propositional-truth rather than concept-truth.<sup>15</sup>

Whether or not the notion of concept-truth should be assimilated to that of propositional truth, the two notions share a core feature. Like his concept-truth, Gassendi's propositional-truth requires agreement between two relata to ensure that bearers of truth-value—in this case, propositions—are true.<sup>16</sup> To begin with, he defines propositions as judgments made by the mind, consisting in a joining of agreeing ideas (affirmation) or a separating of discordant ideas (denial), and featuring a subject-predicate form joined by a copulative 'is' or 'is not'.<sup>17</sup> Accordingly, propositional truth consists in the agreement of a judgment or statement with its subject: "That proposition is true which declares to be the case what is the case, or declares not to be the case what is not; and conversely, that proposition is false which declares to be the case what is not the case, or declares not

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<sup>14</sup> What Gassendi is suggesting is that, lacking a means of detecting agreement with their referents, it is mistaken to speak of them as 'true' concepts. Thus, we might have a concept of unicorns or dancing mice but since there is nothing that these concepts actually represent, there is no means of judging when or why we should accept that they are 'true'—or 'false', for that matter.

<sup>15</sup> It is tempting to interpret this passage as Gassendi wholly disavowing his notion of concept-truth—an appealing interpretation given that contemporary truth theory features no such notion. Yet that leaves as a mystery why Gassendi earlier discusses just that notion as a live option. Moreover, as we see below, in his discussion of a criterion of the senses, he is neutral about whether the criterion is picking out concepts or their propositional expression as true. Finally, one should be cautious about ruling out concept-truth on the grounds that lacking actual referents renders the truth of concepts obscure, for the same holds of a variety of propositions that we would likely want to think of as true or false, such as moral judgments. For Gassendi, as a thoroughgoing empiricist, that variety of propositions should be narrow indeed.

<sup>16</sup> The truth-criterion Epicurus proposes relative to theories about the nature of the world also draws on agreement—in this case, with the phenomena to be explained by the theory (q.v. *Pyth* 86, 93, 96; *Her* 50–51; Asmis (1984), 178). This is a standard for judging theories that Gassendi adopts and develops as well; cf. chapter 6.

<sup>17</sup> If propositions do not have that form explicitly, they may be reconstructed accordingly—so that 'man is' may be understood as 'man is existing'. *O I* 99b–100a; *IL II*, 102–3.



to be the case what is.”<sup>18</sup> Gassendi’s view closely follows the Stoic and Epicurean conception of truth which, as Chisholm has indicated, remarkably well anticipates the Tarski-Carnap truth scheme,

(TC) “x is y” is true if and only if x is y.<sup>19</sup>

Indeed, this element of Gassendi’s view even presages a full-blown disquotational theory of truth, as it apparently entails a view of truth as consisting only in that property in virtue of which we assign truth-values to instances of something like (TC).<sup>20</sup> No other properties—semantic, pragmatic, or otherwise—enter into this account of what truth is. A principal difference is that Gassendi is concerned in this context with only one of a class of differently defined truth types, whereas the contemporary theory ranges over a singleton class, that of propositional truth.

With this last approach to truth, we are now closer to the contemporary conception of a truth-property, according to which truth is an attribute of beliefs or propositions. For Gassendi, what ties this kind of property to properties of concept-truth and object-truth is that they are all, at least crudely, some measure of the accuracy of a reported item or state of affairs.<sup>21</sup> Still, concept-truth and object-truth differ starkly from propositional-truth in that their objects need not be expressible in propositional form. Thus Gassendi’s truth property, insofar as it can be construed as a unitary property, cannot be quite the same as the property of interest in contemporary epistemology or philosophy of logic.<sup>22</sup> Although these different kinds of

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<sup>18</sup> *O* I 100b–101a; *IL* II § I, 104–6.

<sup>19</sup> Roderick Chisholm, “Sextus Empiricus and Modern Empiricism”, *Philosophy of Science* 8 (1941), 371–384. Q.v. *O* I 68a; *B* 287.

<sup>20</sup> For varying contemporary defenses of a disquotational theory, q.v. Paul Horwich, *Truth* (Oxford: Blackwell, 1990) and Hartry Field, “The Deflationary Conception of Truth”, in *Fact, Science and Morality*, ed. Graham MacDonald & Crispin Wright (Oxford: Blackwell, 1986).

<sup>21</sup> This claim reflects his view that all warranted empirical belief is rooted in experience. Given that all propositions are composed of sensory-based ideas, the viability of such compositions consists at least partly in the degree to which experience supports the relations (agreement or disagreement) of ideas in a given proposition.

<sup>22</sup> In historical and contemporary senses, there is another notion of concept-truth available, which amounts to a form of analytic truth. One example is Anselm’s Ontological Argument, where an appeal is made to what must be true of God according to the very concept of God. Yet this is sort of concept-truth is easily

truth are not all relevant to our own, present-day notion of what truth is, nonetheless Gassendi offers an intriguing picture of the sorts of veridical character with which one should be concerned if one is to include among the knowable items not just propositions, but ideas and even concrete objects. The pressing question is then what it could possibly mean for someone  $x$  to know, for example, an idea  $p$  without standing in the relation ‘ $x$  knows that  $p$ ’ and  $p$  having one or another propositional form. As we have seen, Gassendi also has doubts about the feasibility of applying a truth-predicate to non-propositional items.

A broader caveat to Gassendi’s view of truth is that while he takes it to be a detectable property of the objects of knowledge (particularly relative to empirical knowledge), he cannot accept that we can know conclusively that beliefs about appearances actually are true. This is because he views truth as an essential quality of appearances (per the Epicurean stance) yet holds that we have no knowledge of essences.<sup>23</sup> However, Gassendi appeals to verisimilitude where truth itself is unavailable to us. In short, we know a given belief about appearances resembles the truth in accordance with its measure against other experiential information.<sup>24</sup> Any optimism here must be tempered by the passing nature of warrant. Although we may hope to attain many such approximations to the truth, the resulting characterizations of the world are always a tad amiss. The problem is worse than not being able to attain absolute truth given our modest intellects. For Gassendi, we can never even land on a solid candidate for the truth with any permanence:

... on the truth itself I never pronounce myself, feeling incapable of discovering it; I am thus a man who holds no resemblance to the truth

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folded into propositional-truth, in that the truth-value in question ranges over a subject-predicate structure.

<sup>23</sup> I discuss knowledge of essences below. It may be argued that the reasoning here is incomplete, as not knowing the essential truth property of appearances does not entail not knowing the truth property of *claims about* appearances. While this appears to be a misstep, our inability to know the truth of appearances has a corrosive effect on our putative knowledge of appearances, which directly undermines our ability to judge the truth of claims about appearances.

<sup>24</sup> *O* I 79b; *B* 326–327. Passages referring to verisimilitude as satisfactory where we lack the truth are sprinkled throughout Gassendi’s oeuvre; for example, q.v. *O* I 286b and *O* III (*PGDA*) 636a–b. ‘Truth-like’ (as against ‘true’) propositions may be veridical on a broad spectrum; on a binary scheme, they are simply false. Gassendi’s epistemological framework assumes just such breadth, though, allowing for approximation to the truth.

as warranted strongly enough—I am not entirely ready to give warrant away, if there arrives another [candidate] that appears to have greater weight.<sup>25</sup>

An inability to conclusively assess the truth of our beliefs might well have been an embarrassment to Gassendi's efforts to identify secure foundations of knowledge. In his view, though, beliefs may be acceptable though they are not conclusively identified as absolutely true. Instead, the viable beliefs are established by criteria that gauge approximate truth.

Gassendi's proposed truth-criteria are not marks or characteristics of truth *per se* but cognitive 'instruments of judgment'. The problem of the criterion, he proposes, is historically the problem of determining which of our cognitive faculties, if any, can serve as instruments for determining the truth. He adopts the faculties view of criteria promoted by Epicurus, identifying the proper faculties as the senses and the intellect (or 'understanding').<sup>26</sup> With our sensory capacities we detect the existence and qualities of the perceptually evident and so gauge the veridical nature of basic appearance-beliefs. With our intellectual capacities we measure whether reasoned judgments about the non-evident, as well as the evident, are true.<sup>27</sup> Although Gassendi eschews the cognitive content view of criteria, however, he designates a central role for the species—a form of cognitive content—in providing warrant for empirical belief. As we see below, this move is not only consistent with his faculties view of criteria; it helps account, at least partly and indirectly, for why the faculties represent the best candidates for criteria.

The principal and direct basis upon which Gassendi suggests that we can posit such cognitively-based criteria is recognition of our

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<sup>25</sup> *O* III (*DM*) 389a; *R* 536.

<sup>26</sup> Gassendi traces this approach to truth-criteria to Sextus Empiricus and the targets of his skepticist critique; q.v. *O* I 69a–b; *B* 291–293. While the cognitive faculties view of criteria enjoyed some currency among the ancients (q.v. note 4), this view eventually lost ground. The Epicureans themselves were inconsistent on this score, suggesting as well that the cognitive content of the *eidōla* (εἰδῶλα or 'species') stand as primitive truths or criteria for judging other beliefs.

<sup>27</sup> *O* I 80b–81b; *B* 290–91. There is a close parallel with Gassendi's distinction between kinds of truth: the senses emerge as the criteria of object-truth, and the intellect as the criterion of the veridical nature of judgments, that is, propositional-truth. While Gassendi does not point out this parallel, his proposed two kinds of faculty-based criteria break into the two respective kinds of epistemic properties that such criteria help identify.

ability to draw warranted inferences from signs. Notably, if we can justifiably infer beliefs about the non-evident from signs, then it must be that some criteria enables us to recognize the (approximate) truth of such beliefs.<sup>28</sup> It may seem that this strategy unfairly hitches the fate of the criterion to the success of sign-based inference. If we found sign-phenomena were instead poor inferential tools we would presumably still want to pick out truths about the non-evident. While in that circumstance there would be, very possibly, *some* criterion, it is unclear from Gassendi's discussion what sort of criterion would determine the truth of such beliefs about the non-evident—or why such a criterion would itself be warranted.

Gassendi does not think this an unfair strategy; he believes that a central, if not the primary, role of epistemic criteria is to enable our identifying the truth of beliefs about the non-evident. We employ the criteria primarily to pick out signs and their significance. Hence the understanding constitutes a criterion of propositional truth, and in particular of judgments concerning what counts as an indicative sign.<sup>29</sup> Here is a parallel between the senses and the understanding, in their respective roles as epistemic criteria. The senses help us gauge the truth or accuracy of concepts of appearances in general, but 'signing' appearances in particular, and the understanding helps us gauge the truth or accuracy of judgments about appearances in general, but judgments relative to evidence for 'signed' phenomena in particular. The understanding serves a further role, as a standard of accuracy between its own judgments and the evidence of the senses. In case the senses should mislead us and present us with an unreliable sign, the understanding can 'correct for' misperception. In this way the understanding can lead us to a more fruitful interpretation of that sign—or else rejection of the corresponding appearances as a sign, after all.<sup>30</sup>

Indeed, in *De Fine Logica* (the introductory portion of the *Logic*), Gassendi goes so far as to claim that the *sole* purpose served by criteria is to pick out viable instances of signs. He contends that the

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<sup>28</sup> *O* I 69b; *B* 293.

<sup>29</sup> *O* I 85b–86a; *B* 347.

<sup>30</sup> *O* I 81b; *B* 333. It may be complained that Gassendi's scheme grants the understanding ill-considered capacities to not only generate judgments but also to weigh those judgments against the evidence of the senses. Whether this is a real problem depends on whether the understanding can generate meta-judgments, uncolored by its initial, first-order judgments.

Skeptics do not look at the problem of the criterion as a route to raising doubts about appearances. The Skeptics at least admit that appearances exist and that we can make reliable claims about appearances, though they insist such claims are relative to how things seem to us. Rather, Gassendi suggests, the crux of their worries is how, if at all, we can go beyond appearances to make claims about what is hidden, and what criterion would allow us to judge that such claims are true—hence the need to identify worthy signs.<sup>31</sup> This is not, as it happens, a plausible construal of Skepticist concerns. They are not so quick to allow that we may have knowledge about an external world beyond appearances. Gassendi's characterization is more accurate as a retelling of the Epicurean position that the proper criterion identifies those primitive beliefs concerning the evident upon which we can build beliefs concerning the nonevident. As Gassendi himself notes in the *Institutio Logica*, the Skeptics are concerned with the possibility of criteria for the broader task of identifying truth as a property of various objects of knowledge, and not just phenomena we pick out as signs.<sup>32</sup>

Historical inaccuracies aside, Gassendi's stress on sign-identification as a core role of epistemic criteria suggests the importance of cognitive faculties in gauging the truth or truth-likeness of empirical

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<sup>31</sup> *O I* 80b; *B* 329.

<sup>32</sup> The Skeptic position on a truth criterion went through several stages of development, as Striker adeptly charts (1990). First, and most 'typically', was the suggestion that there is no criterion—which view prevents not action (as one might suppose if it is not possible to discriminate the real from the unreal, or one thing from another) but *justification* for actions. This Skeptic acts on the basis of appearances, the impossibility of knowledge from or about those appearances notwithstanding (q.v. Plutarch, *Adversus Colotem* 1122d–e; Striker (1990), 155–156). This is what Gassendi refers to as a criterion in the “matters of ethics”, as distinct from criteria for gauging either the existence or truth of a thing (*O I* 69a; *B* 291). While Sextus considers something very like this view, he also introduces the variant theory of Carneades. The Carneadean view is that sensory impressions are criterial in the sense of providing a basis for rational decision and the “conduct of life” rather than for discovery of foundational beliefs or the gauging of truth. Such criteria must be convincing, based on normal and regular perceptual experiences, and not conflict with other impressions regarding one and the same object (Sextus, *Adv M VII* 166–189; Striker (1990), 156). Later, Philo of Larissa attempts to turn the “conduct of life” criterion into a criterion for the plausibility of belief, suggesting that beliefs derived from clear and true impressions may constitute knowledge—*contra* the Stoics—without the need for establishing that such beliefs could not possibly be false. Yet hopes for a criterion receded among Skeptics as they concluded that there might not be any single way to determine what is evident and without need of proof (q.v. Striker (1990), 156, 159–160).

beliefs. When, for example, we judge apparent phenomena as signs of the non-evident, we use the understanding to reach this judgment, which Gassendi characterizes as our employing the criterion of the understanding.<sup>33</sup> This raises the question as to how we are to measure that judgment's resemblance to the truth. Does the faculty of the understanding itself constitute a reflexive criterion, capable of judging the veridicality of sign-identification judgment? Although Gassendi does not address this issue directly, he proposes that the understanding is the 'superior' faculty, equipped for correcting mistakes in perception or judgment thereof.<sup>34</sup> Further clarification along these lines is provided by Gassendi's general designation—beyond the identification of signs—of the understanding as a criterion for gauging judgment. The judgment of sign-identification judgment is then just another instance of reasoned judgment for which the understanding is the designated criterion.

This account is noteworthy in that, as noted above, Gassendi is relatively alone among the moderns in picking out a cognitive faculty—as opposed to the cognitive content of a standard, rule, or exemplar—as a criterion. This move is inspired by those ancients who identify a cognitive faculty as criterion, in particular, following one strand of Epicurean thought.<sup>35</sup> This source of inspiration is routine for Gassendi, but it may be asked why he follows the cognitive faculty view and not the cognitive content view, given that both are found in Epicurean thought. As we will see, the answer can be found in Gassendi's embrace of the cognitive faculties as a means of securing not only the truthlikeness of beliefs but the warrant for holding them, too.

One problem with taking the understanding as a criterion, Gassendi concedes, is that different minds may yield diverse judgments so it is not *prima facie* clear which understanding—in effect, which person—is suitable for serving as criterion, or how to rule out the possibility

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<sup>33</sup> *O I* 81b; *B* 333.

<sup>34</sup> *O I* 85a; *B* 345.

<sup>35</sup> *O I* 69a–b; *B* 290–293; *Her* 38. Striker (1990) suggests that Epicurus instead thought of 'criteria' primarily in terms of the cognitive content of the senses, pre-conceptions (πρόληψις or 'prolēpseis'), and feelings. Pyrrho denies that either the senses or the mind could stand as criteria, yet there can be no other candidates, such that there can be no criteria (*DL IX* 92). The cartesian *cogito* might be taken to indicate a cognitive faculty criterion as well, insofar as mind stands as the test of clarity and distinctiveness. However, Descartes is at least by one traditional interpretation providing a rule-based criterion in this instance, and at all events mind in his broad sense is not a faculty *per se* but a substance.

of diverse criteria. His suggestion in response is that any understanding is suitable if it obeys the rationality constraint that no judgment made yields an absurdity. Thus worthy judgments are those made by the person who “. . . having weighed all considerations, presents an argument that cannot be legitimately contradicted.”<sup>36</sup> This kind of constraint should define the set of suitable understandings, without permitting judgments so divergent as to be incompatible. However, Gassendi does not indicate that, much less how, such a proposal assures this goal, and so opens his view to a number of difficulties. For one, it may be objected that the understanding of one person alone may generate unworthy judgments. For another, it is possible that the set of least-erring understandings may yet yield inconsistent judgments.

Whatever its immediate flaws, Gassendi offers a putative answer to the Skeptic with a picture of the truth-properties he thinks we can identify, and the criterial faculties that enable picking out those properties in the objects of knowledge—concepts and judgments. Given his interest in justifying beliefs about the external world, a natural next move from a contemporary perspective would be to say how—if at all—picking out truth-properties provides the requisite warrant for holding those beliefs. This bit of present-day epistemological reasoning, though, is not an element of Gassendi’s thinking, and he does not suggest that the criteria justify beliefs as a direct result of indicating that the beliefs are true or verisimilitudinous. Rather, his discussion runs together the distinct tasks of providing criteria for truth-properties and norms or standards for belief justification. Nonetheless, he suggests these criteria yield warrant for empirical beliefs, in that the reliability of those cognitive mechanisms—which sustains their performance as criteria of truth-properties—also provides such epistemic justification. His proposal has two elements. First, we justify empirical beliefs by establishing their conformity with other beliefs originating in sense-based ideas. Second, the corresponding sensory information is received under the normal or regular conditions that lend the cognitive faculties—and thus our beliefs—their reliable character. Reliability is the common guarantor of verisimilitude and doxastic warrant.

A cornerstone of Gassendi’s story of epistemic justification is his physicalist account of the capacity for attaining true or at least

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<sup>36</sup> *O* I 81b–82a; *B* 347.

verisimilitudinous empirical beliefs that are reliable despite the varying appearances of objects. Once again, his concern here is historically based: the same varying appearances problem faces the Epicurean position, and is seized upon by the Skeptics.<sup>37</sup> Yet it is also a core concern for any view of warrant that rests on the reliability of appearances. The Epicureans are well aware that appearances of the same things vary, or at least seem to vary, because distance creates perceptual distortions. Gassendi's Epicurean solution, as we have seen, is to propose that we perceive something  $x$  when our eyes are impacted upon by material species corresponding to  $x$ , which are transmitted to us as light corpuscles arranged in particular ways so that they represent the features of  $x$ . As a result, the distance between ourselves and  $x$  affects our perception by enhancing or diminishing the quantity and quality of the rays of light carrying the representative corpuscular arrangement, and this correspondingly enhances or diminishes the qualities of  $x$  as represented and transmitted by the species. Thus species in our field of perception yield larger images of closer things and smaller images of further things. This physicalist model accounts for cases such as the tower perceived as round from a distance and square close-up: at short distance, the rays hitting our retinas are sufficient in number to yield images of the many edges we must perceive to distinguish the shape of a square tower, but from far away, fewer such rays reach our retinas, with the result that we perceive fewer edges—and judge that the tower is round. It is not because the senses err that we come to this judgment but because the tower's corners are indistinguishable under normal conditions by normal perceptual processes. Thus while our belief that

(i) “the tower is round”

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<sup>37</sup> Indeed, as Everson points out, critics have tended to judge the Epicurean response to this problem against the Skepticist view that our conflicting impressions of the same items entail that they cannot possibly all be true (that is, yield access to the hidden nature of the thing appearing to us), and all sensory impressions are subject to this line of reasoning. This is an anachronism, given that the Ten Modes are fashioned some 200 years after the Epicurean view is developed, such that the early Epicureans could not have been expected to reply to that Skepticist response in particular (Everson (1990), 162–164). Gassendi, of course, had a broader palate of responses, and he answers the Skeptic's challenge by offering a way of discriminating among perceptions as viable evidence of the hidden—an Epicurean view offered directly in response to the Skeptic—as well as the strictly Epicurean (that is, pre-Skeptic) view that our sensory perceptions are never false.



is unjustifiable by the evidence before us—and also false, our belief that

(ii) “the tower appears round to us”

is not only *not* false—the physicalist account suggests we can be justified in this belief as well.<sup>38</sup> As in contemporary reliabilist theories of epistemic warrant, Gassendi takes the normal state of our perceptual processes—that they work in accordance with well-defined constraints and sub-processes—to be one guarantor of beliefs. The other guarantor typical to reliabilist theories of warrant is the *regularity* of those processes—that they consistently produce beliefs that are not in error.

For Gassendi—like the ancient Epicureans—the very possibility of error in empirical judgments does not arise in the first-order collecting of information, from the senses. Thus, although one may be in good company for taking false empirical judgments such as (i) as cases where the senses err, Gassendi’s view is that senses are not the source of any difficulties here. Rather, the understanding produces a judgment about the nature of a thing without properly assessing the relationship between the thing and its appearances, so that we are unable to accurately establish “. . . which of the different appearances produced in the senses . . . is in conformity with the thing.”<sup>39</sup> By contrast, the senses cannot err since they apprehend appearances—which are themselves always true—but do not make judgments about them.<sup>40</sup> The locus of such judgments, and so the plausible locus for

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<sup>38</sup> O I 85a; B 344–45.

<sup>39</sup> O I 85a; B 345.

<sup>40</sup> Two arguments are typically attributed to Epicurus for the claim that perceptions are always true. First, an ‘epistemological’ argument suggests that if some perceptions were false, then all perceptions might be false, given that their evidential value is uniformly equal, stemming as it does from the same source—our perceptual apparatus. Indeed, they all share an equally absolute evidential value, for if they did not, countervailing perceptions could be grouped and weighed against one another (DL X 32; Everson (1990), 170–171). Two problems here, as Everson points out, are that there is no argument offered for taking all perceptions to have absolute value—and at all events, given an inability to discriminate between true and false perceptions, there is no *prima facie* reason to prefer the Epicurean position that they are all true over the Skeptic position that they are all false (Everson (1990), 171–172). A second argument is based on the Epicurean causal account of perception: We perceive properties of external objects in virtue of those properties themselves being imprinted on our passive sensory receptors by the object’s ‘image’ or species (*eidōla*),

consistent production of belief without error, is the understanding—particularly in its judging the conformity of different possible appearances with the thing which appears to us.<sup>41</sup> On this reading, a second source of epistemic warrant—the regularity of our beliefs not being in error—is the consistent judgment by the understanding of such conformity of appearances.

One potential difficulty this reading raises is the possibility of a justificatory regress. If whatever justifies such judgments of conformity is another judgment by the understanding, then we still need something else that warrants *that* judgment, and we should hope that it is not yet another judgment. A natural response given the justificatory strategies we have visited so far might be that the regularity of cognitive mechanisms provides this warrant, but there is at least a hint

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hence the perceptions must be true to the properties in question, for species communicate just those properties. Opinion, as subsequently added to perception, is a source of falsity and error (DL X 50, Everson (1990), 172–173).

Conflict among perceptions is not possible on the Epicurean view because that conflict just turns out to be the discrepancies between different objects of perception or species tokens (*Her* 48–49; Sextus *Adv M VII* 206; Everson (1990), 175–178). Accordingly, the skepticist modes can be reduced to modes of distortion among species—and this is a view Sextus promotes and Gassendi later shares. This model of conflict avoidance clearly depends on the strength of the Epicurean account of perception, which offers no *immediate* connection between what is perceived and the external object from which the species emanate. This gives rise to two questions, which Gassendi must address insofar as he offers a very similar causal account. First, absent an account of the representational qualities of species, it is not clear how the Epicurean account of perceiving *them*—rather than the external objects themselves—yields a causal account of knowledge; this question Gassendi attempts to answer by way of his mechanical account of species. Second, as Plutarch first demanded (q.v. Striker (1977), 14; Everson (1990), 179–180), it must be clarified how the Epicurean view is supposed to be a theory of knowledge of external objects, where knowledge entails true belief, given that the communication vehicle of the species features distortions along the way.

One proposal is that it is possible to arrive at truths concerning external objects on the basis of ‘true’ species-based perception given sufficient attention to the nature of evidence the senses provide to our picture of the world (Everson (1990), 180). In particular, we may arrive at such truths if we are aware how greatly distortions of the species affect the communication of properties from external objects to our sensory receptors.

<sup>41</sup> This view has an Epicurean precedent in the suggestion that the understanding forms judgments about empirical claims by combining and contrasting ideas based on sensory perceptions (Sextus, *Adv M VII* 211 and *DL X* 30). Gassendi’s proposal goes further, suggesting that the understanding yields judgments as to the merits of empirical claims that entail assertions about the fundamental nature of the objects of such claims. Within an Epicurean framework this proposal would be plausible only if the understanding could contrast such assertions (as are based on the senses) with information based on *prôlepses*.

of circularity here. In any case, Gassendi himself is silent on the matter. A further difficulty for this proposal is grasping how, in his view, the understanding might recognize the nature of a thing itself—and so render the conformity judgment—apart from any of its appearances. Indeed, if we had such access to those natures, we ought not need empirically-based judgments to characterize those things for which we already had adequate, non-empirically-based pictures. It seems that in this context Gassendi trips over his own injunction against knowledge about the world without and beyond appearances.

It is also possible to read Gassendi's proposal, perhaps more charitably, as allowing that judgments about experiential information (produced by the understanding) are not in error if they conform to other, experientially-derived beliefs, made under normal circumstances. (Again, 'normal' characterizes the circumstances for deriving such beliefs with working sensory apparatuses.) This reading suggests that judging the conformity of a thing's appearance with the thing itself amounts to directly composing a judgment of the understanding that concerns empirical matters, drawing on other beliefs based on empirical data. There is no pretense here of grasping the nature of things via judgments wholly divorced from experience. Further, the burden of gauging error in failure of conformity is shifted to determining whether the perceptual circumstances were demonstrably normal, that is, whether the relevant sensory apparatuses were operational. If so, then such beliefs as were derived using those apparatuses would be error-free (hence warranted), and any nonconforming judgments would not be.

As with contemporary reliabilism, this proposal may well account for what is necessary for lending warrant to beliefs—just in case the normal functioning of our perceptual apparatuses is required to guarantee error-free empirical judgment. Yet, just as with contemporary reliabilism, this proposal clearly fails to specify what is sufficient to that end, beyond the presence of normal conditions and reliable production of true beliefs. For the reliabilist, of course, that is sufficient enough.

In light of the remarks above concerning the 'superior' faculty of the understanding, one outstanding facet of the cognitive faculty model of criteria and epistemic warrant is Gassendi's conception of the *perceptual* faculties as the ultimate arbiters of empirical claims. The understanding performs all manner of operations on sensory information—compiling, generalizing, abstracting—and functions as

the truth-criterion relative to a large class of beliefs. Yet it is the senses that provide the constituent ideas, standard of accuracy, and ultimate source of warrant, for judgments about the world. Gassendi makes an unusual appeal to the authority of the Stagyrite in proposing that we use experience and observation to correct mental judgments:

... when it sometimes happens that reason seems to be in conflict with the senses, Aristotle teaches most strikingly that we must decide more on the basis of the senses than on the basis of reason; this because such reasoning cannot really penetrate the matter, but remains only apparent, while the real reason why the matter appears as it does to the senses lies hidden.<sup>42</sup>

Purely reasoning about some phenomena  $x$  for which we have evidence from the senses  $y$  may yield an 'apparent' account of  $x$  which saves the phenomena, but the underlying, actual reason that  $x$  yields  $y$  is obscure to us, consisting of some causal mechanism unknown and possibly unavailable to us. If we knew what actually gave rise to the phenomena we take as sensory evidence, we would not have to rely on speculative reasoning; since we do rely on such speculation, though, we should be careful to stress its limits. Thus, Gassendi proposes, neither the imagination nor the understanding can lead to certain claims about the causes underlying evident phenomena, for such pure 'penetrating' reasoning about the imperceptible leads beyond all sensory experience, which is the ultimate source of empirical ideas. Hence claims about the underlying causes of appearances attained without the benefit of sensory evidence rely either on baseless conjecture or else clairvoyant access to those underlying causes. Yet if we really had any cognitive access to underlying causes, it would come most naturally through perception first, and the understanding second—if at all.

Gassendi tries to illustrate this position by refuting the armchair intuitions that an arrow shot straight up from the stern of a moving ship would land in the sea, and that people cannot live on the opposite side of the globe without falling off the surface of the Earth. In both instances our intellectual intuitions may lead us astray but can be corrected by sensory information. We can perceive that as the ship moves forward, the arrow moves forward too and so is likely to fall on the ship; and we can find people on the opposite

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<sup>42</sup> *O* I 122a; *B* 372; *IL* IV § IV, 160–161.

side of the globe who have not tumbled off the planet. We tend to reason better in these cases as a function of having more complete sensory information, which suggests to Gassendi that reason by itself is deficient for generating viable empirical claims.<sup>43</sup> Of course, we do not really need either particular sensory information or eyewitness accounts to generate the pertinent physical calculations in these cases; mentally rehearsing the proper thought experiments should suffice to demonstrate the correct accounts.<sup>44</sup> These examples may not be the most fortuitous, and different sensory experiences might suggest claims we could not derive by reason alone. However, Gassendi is clear enough on the matter of empirical claims we even think might be established by acts of the understanding, thought experiments being a primary example. Such claims ought to at least conform to sensory-derived evidence, rather than the other way around.

Unfortunately, Gassendi's presentation of these issues is sometimes opaque, and the conformity relation even seems to run in the opposite direction:

... although it is admitted that the senses are sometimes misleading and that therefore the sign may not be reliable, still reason, which is superior to the senses, can correct the perception of the senses so that it will not accept a sign from the senses unless it has been corrected and then at last it deliberates, or reaches its judgment of the thing.<sup>45</sup>

Here it does not appear that Gassendi sustains experience as the test of reason, and one might infer that he sees the relation between perceptual and reasoned claims as a two-way street, the senses correcting the claims of reason and the understanding correcting perceptual apprehensions. This interpretation misses a subtlety in Gassendi's views, though. The passage in question does not suggest that the faculty of the senses fail as criteria of appearances but rather that our percepts themselves may fail to give us accurate pictures of the external world. Whatever the cause of that failure (as plausibly

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<sup>43</sup> *O I* 122a; *B* 372–373; *IL IV* § IV, 160–161.

<sup>44</sup> Gassendi is certainly familiar with the value of thought experiments (q.v. chapter eleven), though he is perhaps best known in the history of science for physical confirmation (documented in *De Motu*) of an important result first concluded by thought experiment—dropping stones from the mast of a moving ship to demonstrate the Galilean view on terrestrial motion.

<sup>45</sup> *O I* 81b; *B* 333.

external as internal), the effect would be that we mistake particular appearances for signs and so make faulty sign-based inferences. We might better understand this passage as the proposal that the understanding trains the perceptual faculties, as a kind of feedback. For example, by the light of reason, memory, or some other act of post-perceptual cognition we might make clear the distorting effects of abnormal conditions for sensory apparatuses on perceptions of the external world.<sup>46</sup> Were we to discern a way to correct for those conditions, the understanding could then accept the perceptions so corrected as signs from the senses—and thereby the subject of viable judgments. This much is consistent with Gassendi's view of the senses as the source of basic idea-content, veridical character, and epistemic warrant for such judgments. By contrast, the suggestion that the understanding and the senses correct each other neglects his perspicuous and frequent designation of the perceptual faculties as the primary tools through which we know about the external world.<sup>47</sup>

In brief, given the ultimate and thorough dependence of the understanding on sensory information for the contents of judgments, the senses emerge as the *only* tools for discovering empirical truths. Gassendi nominates the senses as the criteria of object-truth and—through the contribution of sensory evidence to judgments of the understanding—the root source of propositional truth. Moreover, the most prized propositional truths are veridical claims regarding the identity of signs, the perceptually evident keys to unlocking otherwise inaccessible mysteries of the non-evident. Looking beyond truth and its approximation, a further theme of Gassendi's account is the appeal to and reliance on experience as a doxastic gauge: all candidates for empirical beliefs are judged against other, better-established empirical beliefs. The crowning empiricist element of this criterial account is that the sensory apparatuses serve to gauge truth *and* justified belief in virtue of the reliability of the senses. Yet in typical empiricist fashion, this enabling feature of the senses is greatly limited, constraining the degree to which we can hope to know the world.

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<sup>46</sup> This is, in effect, the project of *De Apparente Magnitudine*.

<sup>47</sup> The two-way relation interpretation denies Gassendi a coherent cognition model, suggesting that the faculties of reason are at once superior and inferior to the perceptual faculties.

*Probabilist and Anti-Essentialist Consequences of Empiricism*

Two such forms of constraint that stem from Gassendi's account of sensory-based belief and criteria are his epistemic probabilism and anti-essentialism. His probabilism follows from his notion that, while the regularity and normality of our perceptual apparati may lend warrant to empirical beliefs, those features cannot make us *certain* of such beliefs. In *De Fine Logica*, Gassendi chastises the 'dogmatic' philosophers for naively suggesting that such certainty is within our grasp:

... the occasion arises only too frequently in the physical sciences to declare that we are fortunate if we attain not what is true but what is probable ... we feel that in such an incapacitated state it should be considered a great gain if we can rise to the point where we may glimpse not the truth itself (in its very body, so to speak) but some slight image of it, or even its shadow.<sup>48</sup>

Here Gassendi contrasts probability with verity and so conflates truth and certainty modalities. But this seems to be an infelicitous slip, and elsewhere he proposes in straightforward fashion that we can hold justified beliefs about the world with less than complete certainty: evidence that gives empirical belief a sufficient probability of being true may warrant its acceptance. This proposal differs from two other traditional views on the warrant accompanying less-than-certain empirical belief: (i) the Skeptic's non-probabilism, according to which we have no warrant for beliefs which the evidence does not make certain;<sup>49</sup> and (ii) the rationalist's empty probabilism, according to

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<sup>48</sup> O I 79b; B 326–327.

<sup>49</sup> Gassendi supposes the dogmatists to hold this view, too, though they take this as an indication that there *are* warranted beliefs about which we may be certain. As regards the Skeptics, such a view has at least two varieties:

- (a) The evidence for beliefs must yield full certainty but there are no beliefs for which we can have such evidence, because what evidence there is fails to convince;
- (b) There could be evidence for some beliefs that yields less than full certainty, warranting only doxastic suspension and not knowledge *per se*.

Skeptics following the classical tropes held a form of (a), suggesting that evidence from the senses does not yield certainty and so fails to give us empirical knowledge. The Pyrrhonian is closer to (b), suggesting that we have sufficient evidence from the senses to identify possible beliefs about appearances, though we lack any assuredness about such beliefs. The dividing line here is largely the emphasis that those advancing the tropes place on the failure of the criterion, and their concomitant focus on the resulting lack of certainty; in the end, though, these Skeptics too land on suspension of belief.

which, though we might have warrant for such beliefs, there can be no such evidence.<sup>50</sup> Gassendi's reply to these alternatives is that the justification of empirical beliefs does not require certainty of them. It is sufficient to have probabilistic warrant for such claims, attained on the basis of the immediate and reliable nature of evidence from the senses. This warrant is clearly more satisfactory, Gassendi suggests, than that which can be attributed to reasoned judgments (supposed by Descartes and others to yield certain claims) since such judgments are at best indirectly based on sensory information, our surest source of epistemic warrant.

Given the early modern context that predates a sophisticated probabilism, Gassendi offers a reasonably robust notion of what it means for a claim or proposition to have probabilistic or certain warrant.<sup>51</sup> Beyond the quotidian observation that some claims are more likely than others, he suggests we have *probabilistic* warrant for propositions if they are supported by evidence we judge as reliable in virtue of either its frequency or the strength of its witness.<sup>52</sup> On the other hand, we have *certain* warrant for propositions if they are indubitable. He defines certainty as the “sureness of assent which the mind gives to a proposition which it regards as necessary,” which might seem to run together epistemic certainty and an unrelated form of meta-

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The primary Skeptic associated with probabilist views is Carneades, who says there can be more and less plausible beliefs, according to the evidence (Sextus, *Adv M VII* 187–188). Yet his view has been qualified as promoting subjective probabilities—hence from a skeptical standpoint, not possibly yielding true knowledge (q.v. Leo Groarke, “Ancient Skepticism” (2003), in *Stanford Encyclopedia of Philosophy*, ed. Edward N. Zalta (1995–), <http://plato.stanford.edu/entries/skepticism-ancient/>).

<sup>50</sup> This is because, for example, (a) sensory evidence lends support to empirical beliefs that may be confirmatory in a probabilistic sense but does not give us a reason to initially arrive at such beliefs; or (b) nothing counts as sensory evidence for empirical beliefs, because whatever we might standardly take to support those beliefs only compounds our misconceptions about the external world.

Adherents of (a) include rationalists like Descartes or Leibniz. Adherents of (b) include metaphysical Platonists sympathetic to probable belief (naturally, this does not include Plato).

<sup>51</sup> For competing contemporary notions, q.v. Ian Hacking, *The Emergence of Probability* (Cambridge: Cambridge University Press, 1975) and James Franklin, *The Science of Conjecture: Evidence and Probability before Pascal* (Baltimore, MD: Johns Hopkins University Press, 2001).

<sup>52</sup> The view that reliability of evidence is indexed to the strength of witness on its behalf is found in antiquity and medieval law (q.v. Franklin (2001)) and much discussed in early modern British circles (q.v. Barbara J. Shapiro, *Probability and Certainty in Seventeenth Century England* (Princeton: Princeton University Press, 1983) and Serjeantson (1999)).



physical or physical necessity. Yet his concern is actually with what the mind comes to regard as necessary: neither the proposition nor anything it asserts but that the proposition is true. Thus, for example, we may be certain of metaphysically contingent and necessary propositions alike.<sup>53</sup> We become certain of a proposition if we measure the evidence (reasoned or empirically demonstrated) for it and consequently judge that the proposition must be true. For instance, Gassendi suggests, we can be certain of empirical propositions like ‘it is day’ just in case all our evidence from the senses supports such claims and none contradicts it. Here he focuses less on the psychological than on the logical relation between the evidence and the proposition it is said to support, and his notion is that this is some sort of entailment. This suggests that he takes certainty to be a function of logical necessity—unfortunately, not much better of an idea than linking our assuredness to metaphysical necessity. Perhaps the best that can be said of his views on certain knowledge is that he remains true to his empiricism, holding out the possibility of knowing claims with certainty on the basis of whatever evidence from the senses affirms such claims in indubitable fashion.<sup>54</sup>

Among the empirical claims about which we can be certain, one significant range of cases for Gassendi are those judgments we reach on the basis of viable indicative signs. In brief, we should be certain of such judgments because, given the nature of the sign, it is not possible for the hidden phenomena which is the subject of our judgments to be otherwise. Consider once more his favorite case of the judgment that pores exist from the sign of sweat on the skin: “. . . a certain truth does exist, namely that there are pores, and this is demonstrated fully, not from the fact that there are pores, but from the fact that if there were not, two bodies would have to be in the same place at the same time.”<sup>55</sup> Since we cannot admit belief in the physically impossible, and it is impossible for the two bodies—particles of skin and sweat—to be in the same place at the same time, we may adopt an account that enables avoiding such a belief. Thus we (or even should) take sweat on skin as an indicative sign of pores because it allows us to most easily avoid having to accept

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<sup>53</sup> *O* I 103b–104a; *IL* II § XIII, 112.

<sup>54</sup> *O* I 103b–104a; *IL* II § XIII, 112.

<sup>55</sup> *O* I 81b–82a; *B* 347.

the physically absurd. For Gassendi this makes the pores claim not simply a likely story but the only explanation we can embrace, which he takes to be equivalent to a claim of which we may be certain.<sup>56</sup> Certainty is warranted, then, if the claim best allows us to avoid (physically) absurd beliefs.

One obvious flaw here is that any number of alternative accounts might enable us to avoid absurd beliefs, in which case we lack the stated grounds for being certain of any one of the alternatives. A further difficulty is that, while Gassendi's theory of signs promises to give empirically-sound grounds for beliefs about the non-evident, it is unclear how our certainty about such beliefs should follow from the empirical character of the evidence supplied by the sign or even the character of such inferences. More plausibly, our certainty might result from the security of rules like 'do not accept absurd claims', plus a contingent feature of the sign-based claim as contrasted with its alternatives—to wit, that the claim itself is not absurd whereas all the alternatives are. That we can be certain about such claims, on this view, relies not on the strengths of experientially attained belief but on the fortuitous interpretation of a given sign (which, as a contingent affair, is an empirical claim) so as to yield a claim that is not physically absurd.

Looking beyond sign-based claims to those claims lacking certainty, Gassendi advises that we can maintain a proposition with *probable* warrant insofar as it tends "... more toward evidence than obscurity."<sup>57</sup> To better grasp his notion of evidence, it is instructive to consider his suggestion that empirical data (rather than propositions *per se*) are 'evident' if they are incontrovertible hence reliable and therefore enjoy the greatest likelihood. Gassendi recommends this view in a 1642 letter to de Valois:

Evidence is that which appears to the senses that cannot be subject to controversy—from which it draws its reliability, and in such a way that nothing is more probable.<sup>58</sup>

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<sup>56</sup> One problem here is that the justification for accepting sign-based inferences of this sort rests on our knowing with certainty other, more basic physical claims—for example, that no two bodies can be in the same place at the same time—for which we presumably require further supporting empirical evidence.

<sup>57</sup> *O* I 104a; *IL* II § XIV, 112–113.

<sup>58</sup> *O* VI 150a (letter 209, July 18, 1642). Here Gassendi promotes the Epicurean notion that opinion is true just in case it is supported by evidence from the senses.

The link between something being evident and maximally probable is a distinguishing mark of Gassendi's general notion of evidence. For Descartes, by contrast, a claim is also evident if clear (and distinct) but such clarity makes claims evident in virtue of making them certain. A further difference, in the case of propositions being evident, is that Descartes sees no empirical component to determining their evident nature, whereas Gassendi ties their gain in probability or clarity to the frequency of the confirmatory support or the strength of testimony for them, such as the reliability of witnesses in their favor. His example is that we might say "The heat will be strong at the next solstice" is probable because we have observed many more instances of the strength of heat at solstice than not, and the frequency of the affirming observations lends the proposition the requisite clarity. And we might take "A swallow has been seen at the equinox" to be probable, despite the low frequency of such sightings, just in case we have a reliable or generally credible witness.<sup>59</sup>

One sizable mystery we are left with is what counts as *credible* evidence. In chapter 6, I address this aspect of Gassendi's account relative to evidence for scientific hypotheses. His general theory of empirical knowledge, though, offers little guidance as to judging the suitability of evidence for ordinary uncertain beliefs of a pre- or nonscientific variety.

Nor does this general theory offer a fully satisfactory account of relations between the available evidence and the degrees of support that evidence affords our beliefs. In the case of commemorative signs, we have but a glimpse of such an account, as when Gassendi proposes that the claims we base on inferences from those signs are supported by the 'proof of experience'. This suggests that we may be no more certain than is justified by our apprehensions of appearances.<sup>60</sup> Unfortunately, though, he never says how evidence from those signs—or from their commemorative affinities to previous phenomenal descriptions—delivers any particular degree of support for those claims.

The story is a little better developed relative to indicative signs, and other empirical claims regarding the evident. Thus, as we have seen, Gassendi holds that it is possible to be certain of such empirical

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<sup>59</sup> *O* I 104a; *II* II § XIV, 112–13.

<sup>60</sup> *O* I 81b–82a; *B* 347.

claims as these sign-based inferences; the support for our certainty in this case consists in our recognizing the putative necessity of such claims. Similarly, he suggests that we can be certain of simple judgments with empirical content like “It is day”, where those judgments have an ‘apparent’ necessity made clear to the mind by the evidence of the senses.<sup>61</sup> Moreover, in an optimistic vein, he maintains that, for all other empirical beliefs, it is possible to have merely probable warrant, in proportion to their clearness to the mind.<sup>62</sup> His view thereby extends beyond the common classical and early modern anti-skeptical view that our best empirical beliefs lack certainty but may be warranted anyway because they are more probable than not, and more probable than the alternatives.<sup>63</sup> As per this common anti-skepticist view, empirical beliefs are warranted just in case there is evidence that gives them at least some significant likelihood. It is further possible that some empirical claims (especially those based on indicative signs) are accompanied by certainty. Gassendi’s root empiricism requires that such certainty does not encompass doxastic fixity, however, and even those beliefs must be revisable if further evidence provokes a reassessment of the sensory datum we have taken as a sign. Gassendi writes:

... though experience gained through the senses remains the supreme criterion upon which we must rely when something is in doubt, nevertheless not any experience whatsoever is to be so regarded, but only that which has been freed from all uncertainty and all doubt and which is so clear that with everything weighed in the balance it cannot reasonably be doubted.<sup>64</sup>

This last point underscores the notion that epistemic certainty in Gassendi’s account is linked to a sort of psychological necessity, rather than to any logical, metaphysical, or physical necessity (or no necessity at all).

For all the support of Gassendi’s probabilism provided by his empiricist framework, one might well think that he has some broader

<sup>61</sup> *O I* 103b–104a; *IL II* § XIII, 112–113.

<sup>62</sup> *O I* 104a; *IL II* § XIV, 112–113.

<sup>63</sup> Q.v. Popkin (1964/1979/2003) and Pierre-François Moreau (ed.), *Le Scepticisme au XVII<sup>e</sup> et au XVIII<sup>e</sup> Siècle* (Paris: Albin Michel, 2001) on competing classical anti-skeptical views of the period.

<sup>64</sup> *O I* 96a–b; *IL I* § XI, 93–94. For example, one might attain further evidence that caused us to revise our assessment of the evidence of the signs.

or functional reasons for maintaining that view. For example, it might be thought that Gassendi needs some form of probabilism to maintain the very possibility of natural or non-revealed knowledge. All our knowledge, he proposes, is ultimately the product of information from the senses (even in fields that are classical candidates for *a priori* knowledge, like mathematics). Accordingly, if we can have no certainty about beliefs based on sensory information, then all judgments should be no more than probable. And if such judgments could not pass as knowledge because of their not possibly being certain, then we should have no natural knowledge at all. By the lights of this interpretation, his probabilism looks like a way to salvage warranted beliefs about the world not attained by revelation. But this cannot be a satisfactory interpretation, for Gassendi holds that there are empirical judgments about which we *are* certain. There may be a range of other plausible suggestions, but one particularly simple interpretation—keeping within the realm of empirical knowledge—is that his probabilism represents a way of accounting for a vast range of judgments (other than the special, certain ones) which we hold even though their supporting evidence cannot make us certain of them. In such cases, he proposes, we rate those judgments as likely—in proportion to the compelling nature of the evidence on their behalf. This is in turn some complex function of its reliability, as gauged by such factors as frequency, credibility, and the strength of any evidence to the contrary. If something like this suggestion is correct, then it turns out that the most obvious functional motive for probabilism is maintaining all and only the judgments that an empiricist stance allows—in short, that the source of his probabilism is his empiricism, after all.

A second, significant consequence of Gassendi's empiricism is his rejection of knowledge of essences of sensory objects. While his thinking variably exhibits essentialist and anti-essentialist strains, in this context it bears mentioning an anti-essentialist aspect of his theory of empirical knowledge.<sup>65</sup> In brief, he suggests that any beliefs we

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<sup>65</sup> This tension in Gassendi's writings shows up in recent commentary, as well; q.v. Bloch (1971) and Osler (1994) for the view that Gassendi promotes anti-essentialism and an allied nominalism, and LoLordo (2001) for the view that Gassendi does not maintain a principled anti-essentialism. In this context I do not consider the strong anti-essentialism of the earlier *Exercitationes*, which reflects a less nuanced anti-Aristotelianism that does not survive intact in Gassendi's later writings.

have about essences we come to by reasoning through abstraction and analogy, concerning individuals and appearances of which we have reliable sensory-derived ideas. We lack direct epistemic access to essences though, so our beliefs about them cannot have the sure footing of judgments that do not rely on either abstraction or analogy.

The reason we lack direct epistemic access to essences of material things is that sensory information about a thing's qualities where our experiences vary intersubjectively cannot yield judgments about those of the thing's qualities which, being essential, do not vary in any way. The locus of this reasoning is his discussion, in the *Disquisitio*, of two classical instances of the relativity of sensory evidence to individual experience—that honey tastes sweet to me, though bitter to you; and that fire seems hot to us, though not so to insects that live near fire. Since different people (or, as with the insects, different creatures) have distinctive experiences, knowledge of honey's taste or fire's heat differs intersubjectively and thus is not a reliable guide to invariable characteristics of, respectively, the honey or fire. In such cases we are familiar with a thing's qualities only as we record them on a subjective basis, so we can know no more than how the thing appears to us.<sup>66</sup> As the Sceptics put it, we cannot rely upon knowledge of appearances to learn about essences. Gassendi, we have seen, rejects the further, radical Pyrrhonian proposal that even judgments as to how honey or fire appear may be without warrant, yet he shares the Scepticist view that whatever the nature of appearance-beliefs, they do not provide a sure guide to anything we might construe as the essences of things appearing to us.<sup>67</sup>

This epistemic anti-essentialism might be taken to constrain the overall range of our empirical knowledge, limiting experientially warranted belief to claims about appearances.<sup>68</sup> However, Gassendi's

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<sup>66</sup> *O* III (*DM*) 388b; *R* 535; q.v. Sextus Empiricus, *Outlines of Pyrrhonism* 1 X. A flaw in this reasoning is that being limited to recording qualities on a subjective basis need not constrain the ability of one person to knowing no more than what the appearances to her yield, just in case (a) she can learn about appearances to others and (b) the acquisition of empirical knowledge is not defined as feasible only through first-hand personal experience.

<sup>67</sup> *O* III (*DM*) 311b–12a.

<sup>68</sup> Osler (1994, 115) proposes that Gassendi hinges his epistemic probabilism on a denial of knowledge of essences (and universals): since we can know only individuals and appearances, our empirical beliefs can only come in the form of probable judgments about observation and experiment. While this is a plausible way to link the two positions, the argument from the relativity of experiences of secondary

account of indicative signs makes clear that he does not subscribe to any such constraints on our epistemic grasp of the naturally non-evident. Moreover, he allows for the possibility of our learning about essences among the naturally non-evident. His atomist views, notably, address the essential nature of matter, and he markedly proposes these views as well-warranted beliefs. As to whether he takes those beliefs to be warranted by experience—as against reason or theology—is another question, which I address in chapter 12.

### *Conclusion to Part I*

In summarizing Gassendi's rich, historically-inflected theories of criteria and warrant, it is important to recall the views of those whom he takes himself to follow. Epicurus and the Stoics offer an early, promising response to the Sceptics: empirical knowledge is possible because our cognitive faculties can judge true from false beliefs and provide the epistemic warrant requisite to sustaining viable belief. What they did not and surely could not have suggested are detailed or vaguely plausible physical or psychological accounts to say how those faculties might provide either truth-criteria or justification for our beliefs.<sup>69</sup> As a central element of his attempt to revive Epicureanism, Gassendi takes up a similar response to the Sceptics two millennia later—and provides an account of the attainment of perceptual beliefs, which he takes to explain, in turn, how we may judge those beliefs as true and warranted. The perceptual account he provides is, incidentally, developed on the basis of a physics (and, in particular, optics of light transmission) he also borrows from Epicurus, but the physiological details and epistemological lessons, problems and all, are strictly his own. Indeed, this account of justification is distinctive in the early modern context, marking him not merely as a proponent of a causal theory—as may be attributed to Descartes, for example—but as an early and significant reliabilist.<sup>70</sup>

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qualities suggests Gassendi rather thinks the inverse—that our inability to know essences results from the limited character of our observations and the types of warranted judgments we *can* make about them.

<sup>69</sup> This is not to suggest a deficit of any kind; it is clear that offering such accounts was not within the scope of their projects as they conceived them.

<sup>70</sup> A causal theory of knowledge says that S knows that (p) if and only if *a*: S believes that (p) and *b*: p is true given whatever causes p. Whereas cartesian skepticism

While Gassendi crafts his views of empirical knowledge in response to basic epistemological questions—one principle source of which is the Skeptics—his theory is not merely or primarily a *negative* view, offered in response to prominent targets such as Aristotle, Descartes, or even (entirely so) the Skeptics.<sup>71</sup> This has not always (or perhaps *ever*) been the prevalent interpretation of his thought. In one recent commentary, McKenna (1993) suggests that Gassendi proposes an alternative to Descartes's brand of foundationalism because the foundation in question relies on the cartesian posit of a completely body-independent seat of cognition—which Gassendi cannot accept. McKenna contends that since Gassendi assigns a significant cognitive role to the corporeal imagination, he needs some non-cartesian way of justifying our knowledge claims. Gassendi's alternative account says no part of cognition is untouched by or not founded in experience because we base all judgments on sensory information, such that the only warrant available to him for our beliefs must consist in sensory information itself. This is an inventive way to tie together two perspectives central to Gassendi's thought but McKenna cannot be correct. For one, Gassendi also thinks there is an incorporeal mental apparatus that also provides warrant for the narrow universe of non-empirical beliefs, namely, our theological and cosmological judgments.<sup>72</sup> For another, Gassendi's reasoning for his account of justification rests on his views, not of cognition broadly, but on the nature of how we know from the senses in particular. Descartes, for his part, indeed holds that we can know some things with certainty only because he posits a pure thinking substance free of the uncertainties and doubts accompanying our imperfect sensory information.

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undercuts this theory, the cartesian theory of knowledge provides God's role as guarantor of *b*. Reliabilism—in Gassendi and elsewhere—goes beyond the putative causal link between our (empirical) beliefs and the facts about the world forming their content, and recommends that (i) such causal processes as produce those beliefs are identifiably reliable (q.v. Alvin I. Goldman, "What Is Justified Belief?", in *Justification and Knowledge*, ed. George Pappas (Dordrecht; Boston: Reidel, 1979), 1–23) and that (ii) such reliability is the primary source of epistemic warrant.

<sup>71</sup> It is easy to read the *Syntagma* as if Gassendi is engaging directly with the ancients—in particular, the Skeptics, Stoics, and Epicureans—yet his audience is very much a contemporary one. This literary device of rehearsing ancient argument in a contemporary voice helps bring alive the classical debates, though at some risk of confusion. Nonetheless, it is clear enough in most places where Gassendi is expressing his own view.

<sup>72</sup> *O II* 398–424, 440–42; q.v. Osler (1994), 67–69.



Gassendi surely rejects both Descartes's mental model and his proposed criterion, but he does not reject the latter as the result of rejecting the former. Rather, he builds his view of truth-criteria and epistemic warrant as part of a broad account of perceptual knowledge the details of which are separable from, if conforming with, the debate with Descartes over the seat and nature of cognition. Descartes clearly held that the physical details of Gassendi's perceptual knowledge account are separable from this debate, for he also offers a physicalist account of perception yet ends up with intellectualive—not sensory—criteria and justificatory norms.

Other commentaries also interpret Gassendi's theory of empirical knowledge as primarily negative in orientation. Brundell (1986), for example, argues that the single most important strand uniting Gassendi's œuvre is the anti-Aristotelianism first expressed in the early *Exercitationes*, and Osler (1994) suggests that a principal motivation underlying Gassendi's view of criteria is the goal of undermining the cartesian picture of certain truths known through clearness and distinctness criteria.<sup>73</sup> Gassendi's theory of empirical knowledge is best understood, however, as a *positive* perspective, in which he fashions a reliabilist account of truth-criteria and epistemic warrant, and a probabilist account of viable empirical judgment—both on the basis of his physicalist account of perceptual belief. Along the way, he uses elements of his theory in response to past and contemporary thinkers; the theory as a whole, however, is startlingly novel for the seventeenth century.

The negative side of this theory bows in the direction of the classical Skeptics: we cannot be conclusively certain about, nor find ultimate truths among, empirical beliefs. But the positive side rejects Skeptical doubt about empirical knowledge in rather robust fashion: such knowledge is possible because we can identify a variety of strengths—normally associated with many of our beliefs about appearances—notably, their reliability, approximation to the truth, and likelihood by degrees. This *via media*—what Popkin calls a 'constructive skepticist' compromise—suggests a practicable if approximate understanding of the world is within our grasp, which stance Gassendi thoroughly embraces as a practicing scientist and chronicler of recent scientific

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<sup>73</sup> One problem with Osler's assessment is that, as we have seen, Gassendi actually thinks some judgments are certain.

exploits. In the following chapters, I outline ways in which elements of his theory of empirical knowledge guide his ideas about observation, experiment, and the use of hypotheses and hypothetical reasoning. How, if at all, does the way we gain perceptual beliefs lend rigor to our method, and provide warrant for our ideas and judgments in the natural sciences?

PART II

SCIENTIFIC METHOD: THE *REGRESSUS*  
*DEMONSTRATIVUS* AND HYPOTHETICAL REASONING



## CHAPTER FOUR

### METHODOLOGICAL PURSUITS: THE *REGRESSUS* RECAST, INDUCTION, AND PROBABILITY

#### *Overview of Part II*

One central source of Gassendi's views of method is his theory of empirical knowledge. It is not, however, the only source. Thus, while he maintains the empiricist notion that knowledge is from the senses, he also recognizes the value of conjecture beyond experience. In the realm of his methodology—especially as reflected in his own scientific writings—such conjecture is of another order of magnitude than what Gassendi develops in his theory of sign-based inference (though with clear debts to that theory). Further, although his overall picture of empirical inquiry is thoroughly deductivist, he defines an important role for nondeductive reasoning as well. We can partly dissolve these tensions by distinguishing between the method he explicitly presents in the *Institutio Logica* (the largest component of Book One, *Syntagma Philosophicum*) and his informal writings on method elsewhere.<sup>1</sup> Yet

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<sup>1</sup> To understand the place of method in a work entitled *Institutio Logica* and ostensibly dedicated to logic, it is helpful to recognize that, broadly speaking, Gassendi expresses some three notions of logic in the *Syntagma*. The first, enunciated in the history of logic section that appears immediately prior to the *Institutio*, suggests a picture of logic along heuristic and didactic lines, in the manner of Ramus, whose theory Gassendi lauds as a guide to organizing and presenting existing knowledge; q.v. *O I* 59a–62b. The second suggests that logic consists in the Aristotelian syllogistic, the understanding thereof, and related methodological concerns. The third suggests that logic consists in the study and use of causal reasoning, and related methodological concerns—this element (which expressly contradicts his *Exercitationes* view) is the principal source of methodological issues discussed in this study. These latter two notions yield the main thrust of the *Institutio* (though the discussion of demonstration in Book IV has clear Ramist debts). They also have great currency for Gassendi, who typically crafts his use of syllogism and causal inference and method after his *Institutio* conceptions, or at least signals that he intends to do so. The same may not be said for his Ramist conception. For although he makes ample use of rhetoric, he does not turn to definition, distribution, or division for the purposes of diagramming or expounding existing knowledge—per the logic of Ramus—in any way that matches his interest in the traditionally Aristotelian conception of analysis as problem-solving.

Gassendi draws on all of these contrary elements when he engages in scientific pursuits, reporting and analyzing observations and experiments. This suggests he is unwilling himself to dissolve these tensions and believes there is better science to be done by straddling the divisive issues, or else, less charitably, that he fails to see how great the divides really are.

In the *Institutio* passages on method, Gassendi follows a traditional view that the syllogism is the preeminent means of scientific reasoning, and adopts with significant modifications the late-Renaissance *regressus demonstrativus* method, which suggests that there are two steps to every empirical inquiry, one analytic and one synthetic. According to Gassendi's rendition of this methodological model in the Aristotelian tradition, we realize each of the primary scientific tasks of discovery, justification, and explanation by identifying the middle term of that syllogism distinctive to the empirical inquiry and particular task at hand. This model takes empirical inquiry to be a matter of demonstrative proof, where the chain of reasoning we pursue in realizing a discovery task is sufficiently closely-knit that by simply retracing our steps in reverse, we may realize as well the justification task. He holds that the reverse is true, too—that we can make discoveries by reversing the steps of their corresponding justifications.<sup>2</sup> The global deductivism of this framework notwithstanding, Gassendi rejects the Aristotelian goal of certain empirical knowledge and attempts to accommodate the merely probable character of experiential data—

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It has been suggested that a fourth notion—a psychologicistic account of cognitive operations, and perception in particular—is a prominent goal of Gassendi's logic; q.v. Fred Michael, "Why Logic Became Epistemology: Gassendi, Port Royal, and the Reformation in Logic", in *Logic and the Workings of the Mind: The Logic of Ideas and Faculty Psychology in Early Modern Philosophy* (North American Kant Society Studies in Philosophy 5), ed. Patricia A. Easton (Atascadero, CA: Ridgeview Publishing Company, 1997), 1–20. Such discussion is indeed a part of the *Institutio* presentation, however, it is by no means the main goal of the work or of Gassendi's conception of logic, as can be seen from the thrust and length of his discussion of the first three elements, and in particular syllogistic and causal reasoning, and their attendant methodologies. Thanks to Daniele Cozzoli for discussions of these points.

<sup>2</sup> If what we call 'justification' steps actually come first then the 'discovery' task does not reveal anything new and the 'justification' has been developed without justifying any previously made claim. As I indicate below, Gassendi thinks that retracing the reasoning in making discoveries yields the corresponding justificatory reasoning because 'justification' and 'discovery' refer to two pieces of reasoning where one is the mirror-image of the other. Hence reversing the one should give us the other. This is what he intends by suggesting that reversing the steps of a justification task reveals the reasoning of a corresponding discovery task.

and nondeductive inference—upon which he believes we ultimately base our every reasoned claim about the natural world.

Indeed, in accordance with Gassendi's theory of signs, we find that conjectural reasoning from signs of nonevident phenomena is one prominent form of nondeductive inference in several of his descriptive and analytic accounts of experimental results. A difficulty emerges in trying to fit these same experimental accounts to the guidelines of his deductivist method—those guidelines are a bit vague, for example, on how we are supposed to identify the syllogism that best captures the reasoning underlying a given scientific discovery. The spotty nature of these guidelines and his discussion of conjectural inference suggests there is much more to be said about method beyond the views expressed in the *Institutio*. Gassendi recognizes this himself, suggesting elements of a coherent perspective on the proper use of hypothesis and hypothetical reasoning.

According to that perspective, hypotheses are conjectures based on available data, and used to suggest further claims about phenomena for which there is no available data. Their empirical basis dictates that hypotheses may be no more than probable, and their conjectural character suggests they may merely *resemble* the truth, which status they attain when they conform with the data. The hypotheses we accept, Gassendi proposes, are those which most closely resemble the truth. This view of hypotheses helps fill a gap in the method of the *Institutio* by outlining ground rules for use of the chief sort of conjectural inference. Yet this view also suffers from difficulties. By the criterion of truth-resemblance alone it is not clear in all cases either how to decide among more than one hypothesis or what counts as sufficient evidence for hypotheses concerning future events. Moreover, this account underscores the aforementioned tensions in his thinking on method generally. First, there is a conflict with the deductivist programme developed in the *Institutio* insofar as reasoning by hypothesis entails conspicuously nondeductive inference, and second, there is a conflict with his empiricist programme insofar as reasoning by hypothesis entails conjecture well beyond experience, and simple inferences to the hidden as based on signs.

In the end, though, Gassendi's empiricism provides the moorings for his reshaping of traditional *regressus* method and his method of hypothesis. One element of that empiricism, a probabilist view, suggests that empirical beliefs may be warranted by evidence that makes them less than certain. This suggestion supports his view that we

may uphold empirical demonstrations as viable though we are tentative about their conclusions. Another element of that empiricism, his theory of signs, licenses inferences about the non-evident on the basis of ideas about the evident. That perspective supports his view that hypothetical reasoning about the non-evident is possible, in part, because empirical evidence can license and lend weight to such hypotheses.

Gassendi's methodological story in the *Institutio Logica* follows in a tradition developed since Aristotle, according to which we attain new findings and lend warrant to claims in science by some combination of analysis and synthesis, or 'resolution' and 'composition'. This tradition was pursued among the medievals but advanced furthest by a series of Renaissance Italian writers who immediately preceded and greatly influenced Gassendi, as well as Galileo, and likely Descartes, too.

### 1. *The Renaissance Tradition*

The Paduan school of medical thought comprised several proponents of a scientific method of discovery and justification known as 'demonstrative regress' (*regressus demonstrativus*), which combines the determining of causes from their effects and the deducing of such effects from said causes. Primary among these proponents were Agostino Nifo and Jacopo Zabarella, who suggest that these steps—rather than being circular when put together—permit discovery of essential causes in the spirit of Aristotelian science, and in the equally Aristotelian recognition that it is not essences but the perceptually evident that is perspicuous to us. What steps could actually lead us from the perceptually evident to the essences of things, and give us a causal story as well? Consider the two components of this *regressus* method, the 'resolution' or 'analytic' step (based on what Aristotle refers to as 'demonstration of the fact') and the 'composition' or 'synthetic' step (based on what Aristotle refers to as 'demonstration of the reasoned fact').<sup>3</sup> The first yields an unsure, conjectural grasp of a set of causes

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<sup>3</sup> The *locus classicus* here is Aristotle's account of demonstration in *PA* 1.13. In this discussion, I follow closely Nicholas Jardine's view of *regressus* method; q.v. "Epistemology of the Sciences", in *The Cambridge History of Renaissance Philosophy*, ed. Charles B. Schmitt, Quentin Skinner, Eckhard Kessler & Jill Kraye (Cambridge: Cambridge University Press, 1988), 685–711.



through analysis of (and, for some *regressus* theorists, induction on) the particulars of their effects—namely, the sensory data. The second yields a certain understanding of the effects as the demonstrated result of those causes. For example, given the framework of Aristotle's *De Caelo* one might seek the essential cause of the circular motion of the stars as follows:<sup>4</sup>

*Resolution step.* Given our observations which indicate that the stars move in circles, we seek the cause of this phenomenon through 'demonstration of the fact' (and possibly induction on our observational data). The suggestion is that, if we begin by considering the predicate 'moving in circles' as the effect, or middle term of a syllogism, all that remains in order to identify the cause is to determine the major and minor terms. Thus:

- (1) whatever constantly moves in circles has property *x*.
- (2) *y* is something that moves in circles.
- (3) *y* has *x*.

Now, from our celestial observations we can replace *y* in premise (2) as:

- (2') stars move in circles.

and now all we need to do is solve for *x*, the cause (and minor term). This task, clearly the critical component of the resolution, is unhappily where the *regressus* theorists offer us the least precise or consistent guidance. Zabarella suggests we discover causes through the purely intellectual apprehension of universals,<sup>5</sup> Nifo proposes that this discovery is based on a demonstration from signs,<sup>6</sup> other possibilities include argument by elimination via disjunctive syllogism (proposed by Pomponazzi<sup>7</sup>) and Aristotelian species-genus analysis (used by Zabarella<sup>8</sup>). Using this last approach, we solve for *x* first by determining that the genus of stars is 'celestial bodies,' and their

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<sup>4</sup> Aristotle develops his examples of demonstration of fact and of reasoned fact around a causal account for the claim that the planets do not twinkle (*PA* 1.13). The example given here (also Aristotelian) illustrates the sometime *regressus* step of searching for the middle term through species-genus analysis.

<sup>5</sup> Q.v. in particular *De Rebus* (1590) and *De Methodis* (1578).

<sup>6</sup> Q.v. *In Aristotelis*, as cited in Jardine (1988), 688.

<sup>7</sup> Jardine (1988) suggests Nifo may have embraced this method as well.

<sup>8</sup> And numerous others, including (as we see below) Gassendi. Zabarella's use of species-genus analysis is a bit sketchy; q.v. Jardine (1988), 691–692.

speciating difference is that they are composed of ether. We need go no further, for it is a cardinal point in Aristotle's *De Caelo* views that ether naturally moves in circles, such that anything made of ether should naturally move in circles. Hence  $x$  is the property of being made of ether.<sup>9</sup> Now, assuming (with Aristotle) that constant circular motion is natural as well, we have a syllogism where we reason from an effect to its cause:

- |   |               |
|---|---------------|
| (1) whatever naturally moves in circles is made of ether. |               |
| (2) <i>stars naturally move in circles.</i>               | <i>effect</i> |
| (3) stars are made of ether.                              | <i>cause</i>  |

Our knowledge of the essential cause is at this stage only provisional, because it ultimately relies on sensory information we introduce in the second premise. This reliance suggests that, whatever the proposed method for discovering the cause, induction should play a background role in resolution given that discovery requires some generalizations on the basis of observed data. Many *regressus* theorists could accept a background role for induction in the context of their ostensibly deductivist resolution steps because they followed Aristotle in holding that we can actually gain certain knowledge from induction, either through complete enumeration or by intuiting the relevant universal generalization. What makes the cause's identity after the reduction provisional for them is not the uncertainties of inductive reasoning but the recognition that other proposed causes might work just as well: the possibility exists that our resolution simply failed to pick out the right cause. Hence the need for a composition step, where we 'test' the identified cause to see if it leads, necessarily, to the observed effect.<sup>10</sup>

*Composition step.* The composition step entails a syllogism, the object of which is to show that starting with the conjectured cause leads inextricably to the observed effect. Thus for our example we now cast the provisional cause—being made of ether—in the role of the middle term, from which we may deduce the effect:

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<sup>9</sup> Here the species-genus analysis yields a causally fundamental classification given that, following *De Caelo*, the attribution of motion to ether is conceptually basic. That is, since circular motion for Aristotle is an essential feature of the stuff of stars—ether—there is nothing we can identify as a more basic cause of circular stellar motion.

<sup>10</sup> In *Aristotelis* f. 6v, as cited in Jardine (1988), 689.

- (1) whatever is made of ether naturally moves in circles.  
 (2) *stars are made of ether.* cause  
 (3) stars naturally move in circles. effect

If the syllogism is valid, the *regressus* theorists suggest, then the effect must follow from the proposed cause such that the cause has been definitively identified and so distinguished from all other possible candidates. This last part is a bit of a mystery, since any candidate cause would also yield the observed effect given that the candidate is chosen through the resolution step and the composition syllogism is constructed correctly. The principle value of the composition step, it seems, lies mostly in affirming (what we should have recognized by this point anyway) that we have identified a plausible candidate in the first place.

Given such problems, it is little wonder, then, that historical moment of the *regressus* theorists was brief, and the theory generally not explicitly featured in discussions of the new scientific methodologies. Yet, as recent commentators have pointed out, this Paduan method of discovery and justification lives on—in modified, covert form—into the early modern period.<sup>11</sup> Perhaps the most prominent early modern

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<sup>11</sup> Q.v. Nicholas Jardine, “Galileo’s Road to Truth and the Demonstrative Regress”, *Studies in the History and Philosophy of Science* 7 (1976), 277–318; and Daniel Garber, “Descartes and Experiment in the *Discourse* and the *Essays*.” In *Essays on the Philosophy and Science of Rene Descartes*, ed. Stephen Voss, 288–310. Oxford: Oxford University Press, 1993.

Mancosu follows Randall and Crombie in accepting a continuity thesis, according to which the principal elements of the Aristotelian view of demonstration outlined in the *Posterior Analytics*, carry over into modern times, largely unaltered; q.v. Paolo Mancosu, *Philosophy of Mathematics and Mathematical Practice in the Seventeenth Century* (Oxford: Oxford University Press, 1996); John Herman Randall, *The School of Padua and the Emergence of Modern Science* (Padova: Antenore, 1961) and A.C. Crombie, *Augustine to Galileo: The History of Science, A.D. 400–1650* (London, Heinemann, 1957). Mancosu is concerned to show how this continuity thesis holds for views on *mathematical* demonstration in particular. He notes that, in the *Exercitationes*, Gassendi rejects the Aristotelian view of mathematics as capable of yielding causal demonstrations, thereby undercutting the status of mathematics as a veritable Aristotelian science (13). Yet the *Exercitationes* is an early work, reflective of strong skeptical leanings. Gassendi’s later writings—including especially *De Proportione* (O III 564–650)—exhibit a clear commitment to mathematical demonstration as a form of scientific reasoning, albeit reasoning that is not ‘causal’ in the modern, physical sense. And in the *Institutio Logica*, he indicates that the *regressus* method has its origins in the work of the ‘geometers’ (O I 121a–b; *IL* Book 4 § II, 158–159). The question may be posed, though, as to what causal explanation *excludes* for Gassendi. In these later writings, he follows a broad Aristotelian sense of *aitia* (αἰτία, generally translated as ‘cause’), typically understood from a modern sensibility as ‘explanation’. In a scientific

writer to embrace this method in a clearly articulated way is Gassendi, in Book IV of his *Institutio Logica*.

2. *On Method: The Contexts of Discovery, Justification, and Explanation*

Gassendi never specifies that we need methods particular to the exact or natural sciences. However, in the last book of the *Logic*, *On Method*, his primary concern is the conduct of practices associated with rigorous scientific enterprise in its various facets—discovery, justification, and explanation.<sup>12</sup> To begin with, he captures at least the element of rigor sought, defining method as “a progression of thoughts organized or arranged in a determined pattern”.<sup>13</sup> This is odd way of putting matters, though it is reasonably close to the more plausible suggestion that method is the set of guidelines by which we determine such patterns. His subsequent discussion bears out this interpretation. Thus, he claims that a theory of method should include all of logic, on the grounds that logic teaches us how to progress “methodically from simple thoughts through propositions to a conclusion arrived at by means of a syllogism.”<sup>14</sup> The central task of our method is to provide a basis for shaping syllogisms we employ in his preferred tools of scientific practice—resolution and composition. In this regard, the most striking aspect of his method is the proposal that we choose to employ resolution or composition in accordance with the way we pursue a variety of epistemic goals (which, in turn, may vary according to our particular scientific pursuits). Accordingly, he asserts, we need a method that is right for the different contexts which together constitute the scientific endeavor—“... sound enquiry and investigation, judicious analysis and assessment of what has been discovered, and formulation of the material in a manner appropriate for teaching it to someone else”<sup>15</sup>. In short,

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context, such causal demonstration should well encompass most any demonstration of explanatory value. Whether, in the end, Gassendi’s view violates the Randall-Crombie continuity thesis depends on how loosely one construes a continuity claim—though his work surely belongs to the same overall tradition.

<sup>12</sup> Needs aside, Gassendi indicates that his proposed method will serve to guide our use of discovery, judgment, and instruction, his examples of each straddling diverse scientific pursuits; q.v. *O I* 120a–124b; *IL* Book 4, 156–166, *passim*.

<sup>13</sup> *O I* 120a–b; *IL* Book 4, Introduction, 156.

<sup>14</sup> *O I* 120a–b; *IL* Book 4, Introduction, 156.

<sup>15</sup> *O I* 120a–b; *IL* Book 4, Introduction, 156.

rules of procedure are needed for the tasks of discovery, justification ('judgment'), and explanation ('instruction'). I consider each of these in turn.

a. *Method in Discovery Contexts: How to Find the Middle Term of a Syllogism*

Gassendi builds his account of discovery on a curiously scholastic view of how to think about questions:

When a question has been posed, it is particularly useful to find a middle term or argument which can be used to determine whether a positive or negative answer is true or false.<sup>16</sup>

Discovery is a matter of finding answers to questions that can be answered only in the negative or affirmative, and the corresponding method will help us determine the truth-values of just such answers. We may think of these questions as 'discovery hypotheses', where a candidate for a discovery is viable only if we can judge it true or false that an appropriately-phrased question is answered either in the negative or affirmative. So, according to Gassendi, one such question as this method should help resolve is "Is man a substance?" This proposal also covers questions outside the purview of first philosophy. Thus "Is the velocity of an object in free fall proportional to the time of the fall?" can be a viable discovery hypotheses. On the other hand, "Is the velocity of an object in free fall proportional to the time or the distance of the fall?" cannot be, for the seemingly inconsequential reason that it may not be answered simply by 'yes' or 'no'. What makes this consequential, after all, is the insurance of minimal complexity in the inquiry. The solution may well be trivial, just in case it poses no great challenge to reconstrue more complex questions as questions with only negative or affirmative answers. Yet the underlying problem such reconstrual addresses is not trivial, underscoring the premium we place on the perspicuous nature of the aims of research.

Gassendi's proposed method begins with the consideration of such discovery hypotheses as the concluding lines of syllogisms, so that the predicate is the major term and the subject is the minor term.

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<sup>16</sup> O I 120b–121a; *IL* Book 4 § I, 156.

The only thing we do not know is the middle term. Maintaining the syllogism as the model of scientific reasoning and focusing investigative energies on finding the missing term clearly preserves a key element of the *regressus* technique. But there is at least one distinctive element to Gassendi's approach. To solve for this 'hidden' middle term and thereby learn the truth-value of a candidate answer to our original question, he proposes that we follow the guidance of a sign.<sup>17</sup> This suggestion is somewhat bare and not much argued but contains an important reference to his theory of signs: the key to finding truth-values for our discovery hypotheses, it seems, lies in grasping and interpreting indications of the non-evident—for example, underlying causes—among the evident phenomena.<sup>18</sup>

Before entertaining this suggestion, let us consider the details of how the discovery method works. Take an acceptable question like "Is man a substance?", and convert it into the discovery hypothesis "Man is a substance"; to find out if this is true or false, we either pursue a resolution step which begins with the subject ('man') or a composition step which begins with the predicate ('substance'), depending on whether we are more familiar with the subject or predicate. Resolution for Gassendi entails a species-genus analysis, so that in this case we may discern that our hypothesis is true on the basis of *man* being a species of the genus *animal*, which is a species of the genus *living things*, which is a species of the genus *bodies*, which is a species of the genus *substances*. Composition entails a similar species-genus kind of reasoning, only in reverse; thus the genus *substances* includes numerous species but only one of which the difference corresponds to *man*, namely *body*, and so on through the genres *living thing*, *animal*, and *man*. By following either procedure we end up with a middle term that fits our syllogistic reconstruction of the reasoning required to discover the truth of the hypothesis—though each route may provide a different middle term, Gassendi notes. Here he suggests resolution yields *body* as a middle term while composition yields *animal*, which provides us with either a resolution-based or a composition-based discovery:

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<sup>17</sup> *O I* 121a; *IL* Book 4 § I, 157.

<sup>18</sup> As noted above, Nifo too proposes, *en passant*, an important role for sign-based inference in *regressus* method. But Gassendi differs from Nifo in firmly rooting his theory of signs in a general theory of empirical knowledge.

*resolution-based discovery*

- (1) whatever is man is body.
- (2) *all body is substance.*
- (3) man is a substance.

*composition-based discovery*

- (1) whatever is animal is substance.
- (2) *man is animal.*
- (3) man is a substance.

And in either case, Gassendi contends, identifying the middle term provides the key to unveiling the hypothesis' truth-value, by establishing the primary supposition necessary for the rest of the resolution or composition step to follow suit.<sup>19</sup>

At this point one might surmise that either resolution or composition alone should suffice to reveal the truth-value of the discovery hypothesis. Whether this is so will depend at least in part on such factors as the middle term candidate consistently serving as the crucial assumption in those *regressus* steps, and the correlation of pursuing any of those particular steps with consistent, viable truth-evaluations of the discovery hypotheses. These possibilities merit examination. However, Gassendi does not explore this scenario and instead further develops his methodological architecture, preserving the *regressus* theorists's link between resolution and composition steps by proposing that one is the reverse form of the other. This suggests that the composition step guarantees results complementary to the resolution step—a problematic claim that weighs upon his discovery method account.

The difficulties with the complementarity claim emerge in Gassendi's discussion of resolution and composition steps as employed in geometry, which he takes to be a fitting instance of his proposed discovery method. He suggests that the 'geometers' use resolution in assuming as true a proposition with an as-yet unknown actual truth-value. They accept the initial proposition as actually true if they can deduce what are otherwise recognizable as true propositions ("something which is true, is agreed to be true, and is virtually a first principle"), and reject the initial proposition as actually false if they can deduce false propositions from it. This much might accurately characterize the 'geometers' in his acquaintance, though their set of 'virtual' first

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<sup>19</sup> O I 121a; *IL* Book 4 § II, 157–158.

principles should have been rather bloated given the deduction of true propositions from false ones. At any rate, Gassendi further holds that the ‘geometers’ use composition when they reverse the steps of a resolution-based deduction, taking in this context the conclusion as the primary supposition to show that the primary supposition of the resolution follows deductively from it:

Synthesis or composition is when they take as their starting point the very place at which resolution stopped and make the same deduction in reverse order, what were formerly consequents now becoming antecedents, the purpose being to build up a demonstration which will prove the initial submission true or false, or the proposed operation feasible or not feasible.<sup>20</sup>

The striking and implausible suggestion here is that, in the natural sciences as in geometry, we can reverse the resolution steps and end up with a mirror-image composition, and vice-versa. This claim may be put: If there is a possible deduction  $x$  of proposition  $\phi_n$  from an ordered sequence of propositions  $\Gamma: \{\phi_j, \dots, \phi_{n-1}\}$  and  $\phi_j$  is the primary supposition of  $x$  (such that all other propositions of  $\Gamma$  ultimately follow from and rely upon  $\phi_j$ ), then there is a possible deduction  $y$  of  $\phi_j$  from a set of propositions  $\Gamma'$  where  $\Gamma'$  contains all members of  $\Gamma$  minus  $\phi_j$ , plus  $\phi_n$ , and in reverse order of  $\Gamma$  (with, as Gassendi proposes the antecedents and consequents of all  $\phi_i$  swapped), and  $\phi_n$  is the primary supposition of  $y$ . This cannot even be true of geometry—otherwise we could deduce any manner of would-be ‘axioms’—much less the natural sciences.<sup>21</sup> Thus it will not work in either field to say that the two steps will lead to complimentary results. If any of this method is to survive, then, at least the suggestion that resolution and composition directly complement one another must be jettisoned.

Happily, Gassendi does not insist that resolution and composition *must* bear these relations for any given middle-term search. Instead, he recommends that we pursue one step *in lieu* of the other, and that which one we choose depends on our relative familiarity with the subject and predicate of the discovery hypothesis (assuming we are not equally familiar with both, in which case it is not apparent

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<sup>20</sup> *O* I 121b; *IL* Book 4 § II, 159.

<sup>21</sup> Though if it *were* true of geometry it would not be surprising for Gassendi to hold it true of the natural sciences as well, since he thinks geometry ultimately constitutes an element of empirical knowledge.



how we are able to choose).<sup>22</sup> So we might best understand the account of the geometer's method as merely an ill-fated instance of employing resolution and composition. In this instance, the relation between the steps Gassendi thinks he has found neither holds in geometry, nor carries over to other areas of scientific exploration.

And what of the search for the middle term, upon which rests our judgments as to the truth-values of the discovery hypotheses? Here, too, there are problems. For one, the prescription of a species-genus analysis (at least according to Gassendi's example) supposes all the information we seek in order to elect a middle term is included, in a fashion, in our conception of either the predicate or subject of the discovery hypothesis. But this supposition founders in the case of countless empirical hypotheses, e.g. 'there are more white swans than black swans'. For another, we cannot pursue a species-genus analysis or synthesis if the predicate and the subject of the discovery hypothesis are not in any straightforward species-genus relation, as in 'only very few white swans have long necks.' Aside from these practical difficulties, it is not entirely clear what, in the context of empirical discovery, the structure of the syllogism contributes to finding out whether our discovery hypotheses are true or false.

Yet the big puzzle in successfully completing a resolution or composition step is how we are supposed to pick a particular term at the appropriate classification level (genus) to be the middle term. It is not much guidance to say the middle term is the one that allows us to fashion the primary supposition of a resolution or composition, if we do not know in advance what that supposition should look like. And if we did, there would not be much point to going through the resolution or composition steps to begin with. But Gassendi thinks there is a way to pick out the middle term, *and* its place in the syllogism, with the help of *sign-based inference*. Though it is not wholly clear what he intends here, a couple of possibilities stand out. First, although the way to define differences that mark speciation is nowhere discussed here, following Aristotle, we may assume that our observational data plays a key role—and in this respect sign-based inference could help us find 'hidden' clues to speciation among our perceptually evident data. Second, if our discovery hypotheses suggest causal relations, we may identify middle terms which were

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<sup>22</sup> *O* I 121b; *IL* Book 4 § II, 157.

previously ‘hidden’ causes, from their effects (as described in the hypotheses) which serve as signs of those causes. These speculative remarks may not match, and exceed the precise details of, Gassendi’s account. All the same, his proposal *simplicitur*—that our scientific discoveries may rely on (sign-based) inference that takes us beyond what is evident to the senses—suggests a nuanced difference with previous methodological views, according to which we make discoveries through the senses alone or through reason alone.

b. *Method in Justificatory and Explanatory Contexts*

Such procedures as may lead us to discoveries can and should be assessed, Gassendi proposes, through what he calls ‘judgment’. We judge that a procedure lends warrant to our discoveries just in case its essential reasoning can be reversed and we can attain the new conclusion from the old one, plus any intermediary suppositions. The hallmark of judgment, then, is that we reverse whatever step we pursued in the corresponding discovery context—if we proceeded by resolution in our discovery process then we proceed by composition in our judgment and vice-versa. A parallel obtains between this suggestion—that resolution and composition compliment one another across methodological contexts—and Gassendi’s earlier, failed attempt to link resolution and composition *within* the discovery context. But here he views the discovery and judgment procedures as distinct, yet related in the way (as he puts it) Theseus views Ariadne’s thread—the discovery procedure is a set of clues left behind in the process of leaving some initial state and coming to rest at a new state, such that retracing those clues in the judgment procedure can lead us to the initial state. Hence for Gassendi the reversal of our discovery step constitutes the judgment step: retracing that first step enables us to assert the viability of the method employed to make the discovery.<sup>23</sup>

His model for this sort of procedural check is no longer geometry but arithmetic, where, for example, we can see if a series of addition operations warrants a particular result by reversing the series and substituting subtraction for addition.<sup>24</sup> Gassendi unfortunately assumes

<sup>23</sup> *O* I 121b; *IL* Book 4 § III, 159.

<sup>24</sup> This procedural feature, which also holds for multiplication and division, relies on the more fundamental property of any pair of commutative binary operations

here that all series of steps we employ in discovery and judgment contexts are reversible, with the same results we can get in reversing series of arithmetic operations. But we cannot insist that our series of discovery or judgment steps have this feature too, unless we stipulate that any such series of steps which constitutes a valid bit of reasoning has a valid mirror-image or even near mirror-image counterpart. And this is false; consider the valid syllogism

All  $z$ 's are  $x$ 's, some  $z$  is a  $y$ , therefore some  $x$  is a  $y$ ,  
its invalid mirror-image counterpart

Some  $x$  is a  $y$ , some  $z$  is a  $y$ , therefore all  $z$ 's are  $x$ 's,  
and invalid (near) mirror-image counterpart

Some  $x$  is a  $y$ , all  $z$ 's are  $x$ 's, therefore some  $z$  is a  $y$ .

Accordingly, it cannot be that a viable judgment method consists in a simple reversal of the discovery procedure.

Yet it is not without merit to suggest that the epistemic contexts of discovery and judgment (or 'justification', in contemporary terms) are related. Independent of the specific relations Gassendi proposes, his *regressus* scheme is notably inventive for allowing that, for each task realized in either of these contexts, the corresponding method is either one of two options, and that the choice of the best method for a task of one given context is an inverse function of the choice made relative to the corresponding task of the other context. The contexts of discovery and justification are not likely related in just this way—if indeed they are distinguishable in this way to begin with. But given that we do pursue different methods relative to each context, Gassendi's view illustrates one way to see them as truly complementary, such that understanding the tasks realized in one should enable us to understand those realized in the other.

In addition to employing judgment to invert and so formally check the procedure of discovery, we also 'verify,' or judge the particular merits of, our discoveries on the basis of experiential evidence. Discovery claims are 'verified' first and foremost by sensory evidence and only secondarily—if direct and immediate experience proves inadequate—by the lights of reason. Thus interpreting signs sometimes

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# and  $\odot$  where # is the *inverse* operation of  $\odot$  and vice-versa, such that whenever  $a \# b = c$ , then  $c \odot b = a$  and  $c \odot a = b$ . Another model Gassendi proposes here is chemical reactions, which he recognizes as reversible in the case of 'mixing' and analyzing metal compounds. *O* I 122a; *IL* Book 4 § III, 159–160.

demands the use of reason though caution is required, for frequently our reasoned judgments lead us to affirm claims that we can later show empirically are false.<sup>25</sup> As an example, Gassendi cites the observations demonstrating that an arrow shot straight up from the stern of a moving ship falls not into the ship's trail in the sea (as we might have reasoned, he suggests) but onto the stern itself.<sup>26</sup> Hence one danger of judging empirical claims—or what he broadly construes here as “discoveries”—by reasoning alone is the possibility that we base such reasoning on the wrong premises, much as the standard Aristotelian account of the arrow shot from the ship is based on the wrong physics. Gassendi upholds sensory evidence as the primary tool of judgment, then, because he worries that justification of empirical claims (‘judgment’) by the lights of theoretically-derived reasoning does not feature the procedural check of independent testability built into our experiments and observations.

The last piece of Gassendi's *On Method* is his account of the context of instruction or what we may think of, at least in part, as explanation. Here he distinguishes between two aims of explanation. The first is to explain practical operations or skills, in order to teach correct performance or production. The second is to explain theoretical investigations, in order to teach correct observation. (In either case, he suggests, there are resolution *and* composition steps.<sup>27</sup>) In the

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<sup>25</sup> *O I* 122a; *IL* Book 4 § IV, 160–161; this is another piece of evidence for holding that the source and strength of reasoning lies in its empirical origins.

<sup>26</sup> *O I* 122b; *IL* Book 4 § IV, 160–161; here Gassendi alludes to the kinematic experiments he describes in *De Motu*, such as dropping weights from the height of a ship's mast.

<sup>27</sup> Thus in physical explanations, we begin by ‘resolving’ natural phenomena and structures into their ‘smallest possible components’, and proceed by ‘composing’ those components into the combinations that yield familiar macro-phenomena and macro-structures. Gassendi provides this analogy:

Let us take as an example someone who is teaching the art of building. He first of all lists the various parts of the house, the walls, the foundation, the roof, the flooring, the ceilings, the sleeping quarters, the stairs, the roof, the doors, the windows, and the rest; next he turns attention to the many kinds of material which have to be provided, stones, cement, timbers, planks, nails, tiles and so on, which constitute the smaller or simpler structural units, explaining what they are, where and how they may be procured, and which are used for the various parts of the building. Next he explains how these parts which he has analyzed are put together by using the stones and the cement for laying the foundation, the timbers for erecting the walls, the planks for the flooring and so on, until the whole house has been constructed. (*O I* 122b; *IL* Book 4 § V, 161–162)

second case, the objective of teaching how to observe follows as a consequence of the appeal that any such explanations, relative to relations and events in nature, must make to empirically-viable theoretical models. A premium on observation is well suited to Gassendi's view of natural philosophy as a contemplative and non-creative exercise, where all performance or production is ultimately in the exclusive hands of the Creator (as mediated by the mechanical action of matter). Such a view is also consistent with his view of astronomy as an exemplary methodological model of contemplative science.<sup>28</sup> Yet the discussion of observation here is incomplete, even against the background of Gassendi's own scientific writings. Neither intervention nor experiment—elements of studying the natural world closely related to observation—are reflected in the method of Book IV. This is either an oversight or else one place where his method and actual forays into natural philosophy are inconsistent. More curious still is the suggestion that the explanatory task most worth clarifying is not addressing how- and why-questions about which natural philosophers or scientists typically wonder, but addressing the question of how we should have come to accounts we present in pursuing the other epistemic tasks of discovery and justification.

In sum, for each of these epistemic contexts Gassendi distinguishes a particular task and proposes a corresponding procedure that employs either resolution or composition (or, in the case of explanation, both). We may consider, by contrast, Descartes's suggestion that resolution and composition play fixed, distinctive roles in a unique method for establishing answers to questions of natural philosophy. According to his proposed method, we should be able to analyze a complex question into questions of greater simplicity, until we reach a question sufficiently simple that it can be answered by an intuition of

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<sup>28</sup> Gassendi writes:

Astronomy is assuredly named thus, as it is concerned with the contemplation and measures of motion, of the stars, and their distance, order, size, light, and other similar aspects.

Admiration of the stars brought about the origin [of astronomy]. This was certain, then, when—aside from their splendor, variety, multitude, and extent—men observed in them the very constant and regular movement, introducing alternately day and night, summer and winter.

The grandness of the matter, once exposed—none other than the very vast and noble region of all the world—gave it its value; in other words, those who contemplate—who keep their eyes closed yet keep their faces turned to celestial matters—are said to be the wiser ones. (*O IV (Institutio Astronomica) 3a–b*)

the mind—this is his resolution or analysis step. Next, we should be able to answer questions of greater complexity by a process of deduction, through a chain of intuitions in which we grasp the relations of, and warrant for, the propositions involved<sup>29</sup>—this is his composition or synthesis step, as identified in the *Rules (Regulae ad directionem ingenii*, 1628).<sup>30</sup> By following these steps, Descartes proposes, we can at once identify causes from their effects (a discovery task), deliver the warrant for believing that we have identified the correct cause (a justification task), and produce an account that answers pressing scientific questions (an explanation task). Thus his method weaves together the principle epistemic tasks of science into one seamless process. But for Gassendi, the tasks of confirming or disconfirming discovery hypotheses and judging our discovery-results do not constitute one inseparable process, and those methods corresponding to the tasks of the distinct contexts are not parts of some single procedure. Indeed, he insures that there can be no single, seamless procedure when he dissociates particular tasks from the designation of resolution or composition as the proper methodological step. For example, though we execute a discovery task through one step and simply reverse that step to execute the corresponding justification task, it depends on our background information as to whether we employ resolution or composition in the first place. And, as another difference from the integrated cartesian model, we combine these two steps to execute the peculiarly Gassendist and metascientific ‘explanatory’ task where what we explain is how we arrive at our discoveries and judgments.

To summarize the key elements of this methodological account thusfar: For one, Gassendi insists that our inferences adhere to syllogistic form—in conformity with the logic theory of his day—and

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<sup>29</sup> Descartes typically takes ‘deduction’ to mean our immediate comprehension of the inferential links between propositions (and their truth). As Garber notes (1993, 292), this fits poorly with our modern notion of deduction.

<sup>30</sup> Whether a given question is an *appropriate* simplification of some more complex question is a function of whether an answer to the proposed simpler one would deductively provide an answer to the more complex one. And given that there are many possible ways to deduce such answers, we need some way to identify the correct deduction. Garber has helpfully proposed that Descartes takes experiment to play this role, in the Baconian manner of crucial experiment. But for whichever answers we attain, we have a foundation (either in basic natural facts, as per the *Rules*; or metaphysical principles as per the *Discourse* and the *Principles*) we can take as certain (either because we have reached them by simple intuition, as per the *Rules*; or because God guarantees them, as per the *Discourse*).

in spelling out elements of his method this insistence yields a strongly deductivist picture of scientific practice or, at least, of the way we best understand that practice (in the manner of what we now think of as rational reconstruction). This might seem to suggest that Gassendi has a strong apriorist streak to his scientific method. Indeed, in a further instance of this apriorism, he recommends that resolution best proceeds by species-genus analysis where we have a good grasp of the relevant essences.<sup>31</sup> However, as I argue in the following section, Gassendi has a manifestly non-apriorist conception of deductive inference which, quite distinctively for his times, suggests such inferences are merely probable, on the grounds that their premises always derive from sensory claims.

An additional element of these methodological views is the proposal that analysis and synthesis might be thought of as inverse methodological steps. He moves from the doomed suggestion that this inverse relation is plausible within the context of a single given discovery, to the only slightly more promising proposal that, if one of the steps is executed in a discovery context and the other is executed in a corresponding justification context, then the two steps should complement one another, as inverse operations. For Gassendi, this relation of the *regressus* steps evinces the core of the relation between resolution and composition: the reasons for evaluating a claim as worthy should mirror the reasons for coming to that claim. This is undoubtedly what the *regressus* theorists who precede him are trying to establish by tying the two steps together—and this also seems to be what is transpiring in Descartes's theory of method (albeit in an altogether different way). There may be great merit in a methodology that allows that the strength of empirical claims is judged, where helpful, in a manner cognizant of the way those claims are established to begin with. Unfortunately for all such *regressus* models, and for Gassendi's rather strong version in particular, however, there is no reason to think this needs to be done by recreating that method of establishment in reverse.

In addition to tinkering with the orthodox *regressus* programme, Gassendi proposes a departure from accepted method when he says we should (i) employ signs of the non-evident to discover crucial and

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<sup>31</sup> On the other hand, as we will see in Part III, grasping essences for Gassendi need not be an apriorist task, given his notion that, whatever little we know of material essences is by virtue of sensory information.

missing information in discovery contexts, (ii) rely on the senses to render final judgment in contests between reason and the senses over justification of empirical claims, and (iii) explain how we attain empirical beliefs by teaching how to observe. Each of these last proposals calls our attention to something missing in the received *regressus* method: detailed guidelines or rules for gathering evidence and judging its support for our empirical claims. In the end, though, these particular proposals are too vague to add much luster to Gassendi's refashioned *regressus* method. One way to further elucidate these proposals would be to supply an account as to how we attain and judge basic information that underlies empirical belief and those inferences by which we establish scientific claims. Such beliefs and inferences both feature uncertainties not accommodated by traditional views of deductive inference, syllogistic or otherwise; hence the desirability of this kind of account in a theory of nondeductive inference. In Book IV, though, Gassendi does not touch on these matters.

c. *Induction and Probability in the Institutio Logica*

Elsewhere, however—in Book III (On the syllogism)—Gassendi recognizes the critical role in resolution tasks of inferring general claims from the particulars of our empirical data—not least from the evidence of signs. Further, he proposes that resolution-based claims are merely probable insofar as they represent individual possibilities among a field of alternatives. In short, some class of syllogisms models inductive reasoning, and another class models probabilistic reasoning. With these suggestions Gassendi builds into his method some features suitable to his own empiricist scientific practice and thinking, and quite distinct from the methodological thought of other Renaissance and early modern writers. For one, he recognizes that inductive inferences inherently lack the information we would need to be certain of the claims they suggest. For another, he proposes that not even deductivist models of scientific inference can insure our certainty about empirical claims because the experientially attained premises we adduce in support of such claims are no greater than probable.

We might think, on the basis of this last notion, that Gassendi has a good enough seventeenth century grasp of inductivist logic, and that it is rather deductivist logic he does not fully understand. Yet, while something is surely amiss in calling deductivist inference 'probabilistic', it seems Gassendi has hit upon a sensible point as



well—that the use of deductive reasoning in empirical contexts, while providing certain formal guarantees, does not insulate empirical arguments from judgment by the measure of belief we invest in their premises. At the heart of this view (which escapes Descartes the deductivist and Bacon the inductivist alike) is a notion suggested by his understanding of reasoning with probability, that the strength *all* empirical claims share is the warrant from experience for any further claims we introduce in their support.

The roots of Gassendi's views on probabilistic reasoning lie, naturally enough, in his views on probability, which in turn stem from his account of empirical knowledge. Let us recall his suggestion that we are justified in (a) inferring claims about one set of natural things and events on the basis of 'signs,' or the sorts of evidence other sets of natural things and events provide, independent of intermediary personal authority or testimony,<sup>32</sup> and (b) characterizing judgments we make about events as more or less probable on the basis of the frequency of those events. These two points are crucial components of what Ian Hacking calls the 'modern' dual-aspect view of probability. As Hacking suggests, accepting the first point is a primary step towards accepting a 'degrees of belief' concept of probability,<sup>33</sup> accepting the second point is a primary step towards accepting a

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<sup>32</sup> This is what Arnauld and Nicole call 'internal evidence', meaning that the evidence consists in some element directly connected to the objects or phenomena without the human mediation of language or other social or psychological factors; q.v. Antoine Arnauld & Pierre Nicole, *The Art of Thinking: Port-Royal Logic*, trans. James Dickoff & Patricia James (Indianapolis: Bobbs-Merrill, 1964); q.v. also Hacking (1975) and Daniel Garber and Sandy Zabell, "On the Emergence of Probability", *Archive for the History of Exact Sciences* 21 (1979), 33–53.

<sup>33</sup> Hacking (1975) contends that acceptance of the sorts of evidence we may adduce from signs contributed to the development of a 'degrees of belief' concept of probability because this acceptance signaled the broadened applicability across scientific areas of study of such earlier (generally legal) doctrines which take claims to be more or less believable in proportion to the credibility of the available evidence (generally personal witness). Some early modern thinkers held that the 'Book of Nature' could be 'read' in such a way as to yield analogous 'witness' for natural things or events not actually perceived. This opened the door for the assessment of all manner of naturalistic claims—previously characterized in the middle ages as either certain knowledge or else unwarranted belief—as credible in accordance with the likelihood ascribed to the available evidence. Beyond Hacking's historical point, it is critical to stress here that the evidence we cull from signs—particularly indicative signs—has a substantial interpretive component, such that the concept of probability the theory of signs should be taken to support is precisely one which says the probability of a claim is the measure of the extent to which we find it to be credible—which is generally conceded to be an at least partly subjective function.

‘relative frequency’ concept of probability,<sup>34</sup> and these two concepts constitute the dual-aspect view.<sup>35</sup> Indeed, something very like a ‘degrees of belief’ conception of probability appears to inspire Gassendi’s proposal that we have warrant for inferences about things and events though we lack certain knowledge of them, and thus his proposal that claims supported by such inferences are “. . . not absolutely definite but assented to with a degree of uncertainty and hesitation.”<sup>36</sup> Claims of this sort are, in the scholastic idiom, opinions (*opinio*): somehow greater than ordinary unevidenced belief if something less than certain knowledge.

Gassendi also offers an account of inductive reasoning, where he suggests we may infer claims about which we are less than fully certain. Yet he does not think induction is a probabilist enterprise: his account of probabilist reasoning is actually deductivist. This is possible because his main concern about the less than certain nature of what he calls ‘probabilist’ reasoning is not with the conditional probability of some claim given our assumptions, but with the probability that we are wrong about those assumptions to begin with. And just in case induction and this sort of probabilistic reasoning seem to meet—as when we embed background inductive reasoning in assumptions of demonstrative syllogism—Gassendi holds that our inferences count rather as deductivist reasoning. In short, to call a piece of reasoning ‘probabilistic’, it is not enough that we can evaluate the merits of the conclusion given our degree of belief in its less-than-certain supporting premises (that *would*, of course, make inductive reasoning ‘probabilistic’ as well). Rather, a piece of reasoning is ‘probabilistic’

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<sup>34</sup> It is a surprisingly recent development, Hacking proposes, to suggest that a claim as to the character of an event has greater or lesser probability as a function of the relative frequency of such events. Hacking argues that this notion of probability arose from practical considerations such as the study of games of chance and insurance statistics, as well as from the principled consideration of claims for which we lack complete evidence. Gassendi’s views offer an early instance of the latter.

<sup>35</sup> Garber and Zabell (1979, 44, 48–50) reject the notion that there is any difference between antique and modern probability concepts, on the grounds that elements which Hacking places at the root of the ‘modern’ view can be found in sources ranging from Quintillian to John of Salisbury. Yet Garber and Zabell accept that this concept, whether we want to call it ‘antique,’ ‘modern,’ or something else, bears these two aspects. What they take as peculiarly modern includes (i) the notion, per Bernoulli, that evidence can be quantified and not simply qualified, and (ii) burgeoning growth in mathematical study of the theory of games of chance.

<sup>36</sup> *O I* 117b; *IL* Book 3 § XVIII, 148.

for Gassendi only in the sense that we draw upon that degree of belief to suggest the fallibility of the conclusion though we recognize that our argument is a valid one; and, in the context of his logic, this recognition occurs only when the argument is an instance of viable deductive syllogism. Whatever the flaws of this view (which I indicate below), it is noteworthy that Gassendi attempts to fit a suitable ('modern') probability concept into a general theory of what makes for adequate reasoning patterns. It is further noteworthy that he focuses here more on the content of inferences and less on their formal character, and that he sustains a theme of his modified *regressus* method in suggesting that probabilist inference may incorporate the demonstrative force of deductive syllogism. This deductivist persistence might be a consequence of his recognition of induction's insecurities. His attempt to characterize a certain class of deductive syllogism as 'probabilist' (however quixotic) is surely an outcome of his global empiricism.

i. *Inductive Reasoning*

In Canon XI of Book III (*Institutio Logica*), Gassendi takes enumerative induction to be the principal means of inductive inference featured in scientific reasoning, and points out that such induction falls short just in case we cannot enumerate all the instances upon which we wish to generalize when making such inferences. In this respect he diverges from the logicians of his day who, following Aristotle's notion of the *epagôge* (Posterior Analytics II 19 100a15–100b5), propose that we *can* get from the set of instances to a generalizing conclusion—via an intuition of the relevant universal. At the same time, he also anticipates an important element of Hume's problem with induction, that justifying any generalization on particulars requires something that may lie beyond our cognitive powers, namely, our empirical knowledge of all such particulars.<sup>37</sup>

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<sup>37</sup> J.S. Milton argues that Humean inductive skepticism arises when the 'intuitive inductivism' of the Aristotelians (whereby universals can be intuited on the basis of inductions) gives way to ordinary, modern inductivism. In the modern view, in lieu of knowledge of actual universals, the aim is to attain knowledge of universal propositions or generalizations, which knowledge can be probable at best. Hume denies that there is a rational basis altogether for establishing such generalizations; q.v. J.S. Milton, "Induction before Hume", *British Journal for the Philosophy of Science* 38 (1987): 49–74, esp. 72–73. Gassendi, for his part, offers an important step towards Hume's position, by developing a model of modern induction for which, as he proposes, we have only as much warrant as that which we impute to the generalization

Broadly, Gassendi views induction as a kind of reasoning which, in his typical fashion, he models along the lines of syllogism, and the salient feature of which is that the concluding line is a generalization on enumerated members of a given class. Each such inference relies on the typically unexpressed but requisite premise that all members of the class so characterized have been enumerated. This much resembles the prevailing Aristotelian view. He steps away from that view, however, when he suggests that it is this reliance which produces the principle difficulty with inductive inference: we could never insure that we have given such an enumeration. If we could, then our reasoning would be demonstrative and thus of an altogether different sort.<sup>38</sup> One way around this difficulty, Gassendi proposes, is to posit the conformity of all remaining unenumerated particulars. This proposal (which he attributes to Lucretius and Horace) nevertheless has only the force of a helpful supposition, and his only suggestion as to its warrant is its utility: “. . . because . . . it is exceedingly difficult, not to say impossible, for there to be a complete enumeration, when some have been enumerated . . . you suppose that apart from those enumerated there occurs none which is different.”<sup>39</sup>

In addition to classical enumerative induction, there are two other forms of reasoning Gassendi suggests are cases of inductive inference; argument by example and argument by witness or testimony. Argument by example easily fits into the class of inductive reasoning because it entails the enumeration of one case plus the implicit inference rule that we should generalize on the single case given. Argument by witness or testimony is even closer to the classical sort of inductive reasoning, the principal difference being that collecting witness or testimony are special, second-hand instances of the practice of enumerating bits of evidence on behalf of a claim. Thus he believes we might accept that the sun’s size is greater than the earth’s on the basis of testimony from Archimedes and other mathematicians

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or unenumerated particulars. This in turn is a function of the strength of our analogy between those particulars we experience and those hidden to us.

<sup>38</sup> *O I* 113a; *IL* Book 3 § XI, 137.

<sup>39</sup> *O I* 113a; *IL* Book 3 § XI, 137. The Epicurean background, which Gassendi has curiously omitted in this passage, is developed by Philodemus in *De Signis* (35–36). The notion is that induction is viable when the inference draws on particulars which vary not at all relative to the features addressed by the inductive claim; q.v. Milton (1987), 55; Asmis (1984), 209; Allen (2001), 208–209 ff.

simply because we accept the premise that “*What Archimedes and the rest of the mathematicians hold must be accepted as true on the grounds that they speak as experts in the science.*”<sup>40</sup> It is not obvious, though, why we should accept what is ostensibly argument from authority as viable inductive reasoning (or viable reasoning altogether) unless, as with argument by example, we are allowed to generalize on a fairly narrow set of cases. Something like this thought must underlie Gassendi’s account, since he holds that what links all these forms of inductive reasoning is their common inferential move—which, he stresses, is at the same time their common weakness. Each purports to take us from particulars to generalizations yet each is missing a premise: the elusive generalization step.

ii. *Probabilistic Reasoning*

By contrast, Gassendi does not think ‘probabilistic reasoning’ is missing any premises—nor does he think it is, in the main, nondeductive. He proposes that what makes a bit of reasoning probable, or ‘suasory,’ is that its premises are contingent and therefore persuade us of the conclusion’s truth, while still leaving some element of doubt.<sup>41</sup> The measure of strength for such inferences is a function of the degree of clarity and certainty we attribute to the premises, rather than the conditional probability of the conclusion given that the premises are true. By adopting this measure Gassendi classifies as ‘probabilistic’ *all* deductive inferences from empirical premises, save those grounded in viable demonstration by induction on particulars.<sup>42</sup> Other empirical syllogism (of a non-demonstrative character) is also premised on information from the senses which, however otherwise well-warranted itself, fails to transmit that warrant in any way that would make us certain about the resulting reasoning. Such uncertainty may arise, Gassendi proposes, where persuasion relies not on compulsion by demonstration, but on trust in the person presenting the reasoning:

The fact that this persuasion may be at one time stronger, at another time less so, depends upon a preconceived opinion or conviction concerning the truthfulness of the speaker . . . the trust we have in a man, although to a degree it is sometimes reliable, is always accompanied

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<sup>40</sup> *O I* 113a; *IL* Book 3 § XI, 137.

<sup>41</sup> *O I* 117b; *IL* Book 3 § XVIII, 148–149.

<sup>42</sup> *O I* 116b; *IL* Book 3 § XVI, 145–146.

by a degree of uncertainty, which stems from a prior knowledge that there is nobody who is unable to deceive if he wishes.<sup>43</sup>

Our awareness that the presenter may be unreliable or even deceitful should lead us to withhold certainty from the premises presented, hence to any claims thereby inferred.

One problem here is that, if this is all it takes to render a piece of reasoning as ‘probabilistic’, then presumably any inference where it is merely possible that the premises are false, and not just those based on empirical claims, could count as well. Thus this view fails to pick out anything special about deductive inference in specifically empirical contexts. It is not clear that this is a failed intention on Gassendi’s part, but it is also unclear that he wants the suatory to extend to the non-empirical, particularly if that reaches to cosmology or theology. Moreover, it is a consequence of this view that, within the realm of viable, probable syllogisms, there is no more prohibition on inferences that are not definitely *false* than there is on those that are not definitely *true*. An inference such as

- (1) Primes are divisible only by themselves and one.
- (2) *Four is prime.*
- (3) Four is divisible only by itself and one.

should be considered as merely ‘probabilistic’—in this case, likely to be false—because the conclusion is based on a premise that we cannot be certain is false (recall Gassendi’s proto-Millian stance towards the learning of mathematical truths and our resulting incertitude about them).<sup>44</sup> At this stage, it may seem that Gassendi understands ‘probabilistic’ reasoning to cover an extraordinary and not terribly useful range of cases.

But Gassendi actually conceives of ‘probabilistic’ reasoning more narrowly. For one, inductive reasoning—an allowed form of ‘scientific’ or ‘demonstrative’ reasoning—cannot count as ‘probabilistic’, surprisingly enough, just because it is missing the all-important generalization step. Indeed, it turns out that a given piece of reasoning is persuasive and contingent only if it meets specific criteria, which

<sup>43</sup> *O* I 118a; *IL* Book 3 § XVIII, 149.

<sup>44</sup> It might be thought that this particular instance belongs to what Gassendi calls ‘paralogism’: “. . . it proceeds contrary to reason by supposing as true and necessary premises that, though they appear to be so, are in fact not so, on account of some implicit and hidden fault in them.” *O* I 119a; *IL* Book 3 § XX, 152.

only deductive syllogisms can satisfy; accordingly, any inference we call ‘probabilistic’ we must already classify as a species of deductive syllogism. What are these criteria? To determine that reasoning is probabilistic requires that we identify the standard sort of relation of the middle term to other terms, which is only possible for viable deductive inferences in syllogistic form. Specifically, Gassendi understands a claim as *certain* only if the inference by which we attain it is certain, as merely *probable* only if that inference is probable and, with this understanding, prescribes these guidelines: (1) any claim we validly infer by conjunctive figure syllogism is certain just in case the middle term necessarily agrees with—that is, is the genus, property, or some other crucial feature of—the subject and the predicate, (2) any claim we validly infer by discrete figure syllogism is certain just in case the middle term necessarily disagrees with—that is, lacks any such feature of—the predicate, and (3) any other claim we validly infer by any other figure syllogism is merely probable.<sup>45</sup> What counts as a claim about which we may be certain, then, is not simply that it follows a bit of reasoning in some canonical form of valid syllogism, but that some necessary relations additionally exist among the parts of the syllogism. Thus in the (conjunctive figure) syllogism:

- (1) Socrates is human.
- (2) *All humans are animals.*
- (3) Socrates is an animal.

the conclusion is certain because ‘human’ (the middle term) is the genus of Socrates and the species of ‘animal’, and so necessarily agrees with each.<sup>46</sup> On the other hand, in the (conjunctive figure) syllogism:

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<sup>45</sup> *O* I 117b; *IL* Book 3 § XVIII, 148–149. Conjunctive figure and disjunctive figure are two kinds of categorical syllogism, that is, syllogisms where the order is subject, middle term, predicate. In the former kind, there are three affirmative propositions where the first features the agreement of the subject and middle term, the second the middle term and predicate, and the third the subject and the predicate. In the latter kind, the first proposition is affirmative and the second two are negative, such that the subject and middle term agree but the middle term and the subject disagree with the predicate.

<sup>46</sup> Strictly speaking, the conclusion here is only certain for Gassendi if we can additionally say that the premises are necessary or clearly true, which judgment is independent of any Aristotelian intuition of those universals which yield the species-genus relations in question. *O* I 116a; *IL* Book 3 § XVI, 144–145.

- (1) Rhetoric is an art.
- (2) *Every art is useful to life.*
- (3) Rhetoric is useful to life.

of identical form, the conclusion is no more than probable because ‘usefulness’ is neither the genus of art (the middle term) nor a necessary or universal property of art, such that line (3) cannot follow from (1) and (2) without some residual doubt. As Gassendi puts it, “. . . the mind is unable to assent to the conclusion without a degree of doubt; nor can the premises bestow upon the conclusion greater clearness and certainty than they themselves possess.”<sup>47</sup>

By standard lights, in the syllogism just cited (3) follows *without doubt* from (1) and (2)—and in this it does not differ any from the first syllogism. From this we might conclude that Gassendi simply does not understand what it means to call reasoning ‘probabilistic’, which suggests that this account is a peculiar, incoherent slip in the *Institutio Logica*. More charitably, he means to characterize any deductivist reasoning as ‘probabilistic’ where the actual truth-value of the premises is a contingent affair, and where he takes the very possibility that the premises may be false to entail that we cannot be certain of the claims we infer on their basis. In modern parlance, then, he is picking out the class of inferences which yield arguments we are unable to judge as sound because their premises have undetermined truth-values. Hence calling a bit of reasoning ‘probabilistic’ for Gassendi more reflects limits on the conclusiveness of our epistemic judgments about such contingent matters as appear in the premises than it reflects any structural merits or deficits of the reasoning.<sup>48</sup>

One oddity in this view should arise in cases where premises of what Gassendi takes to be ‘probabilist’ deductive inference incorporate or rely upon what we (and Gassendi) accept as inductive inference. Consider the following inference, based on enumerative induction, which Gassendi accepts as a viable instance of ‘probabilist’ reasoning:

- (1) A speech of Cicero has an elegant exordium, narration, confirmation, confutation, and peroration.

<sup>47</sup> *O I* 117b; *IL* Book 3 § XVIII, 149.

<sup>48</sup> Even so, that he sees reasoning as ‘probabilistic’ only if it is deductive to begin with suggests he has *some* notion of the priority of structure to content in the assessment of reasoning patterns (though he does not quite present it here with the precision of the modern concept of soundness).



- (2) *Whatever has these things persuades.*  
 (3) A speech of Cicero persuades.

Here, too, the premise (2) sometimes fails to be true, Gassendi warns, with the result that “the conclusion is not a necessary one.”<sup>49</sup> In this case, the inference is ‘probabilistic’ and, it seems, inductive. It is not, however, elliptical in the usual (offending) way, for the premise (2) provides the oft-missing generalization step. If cases of induction by this sort of “enumeration of parts” appear to us to count as what Gassendi takes to be induction and ‘probabilist’ inference, this is not to say there are probabilist inferences he himself would concede are inductive. For though we may take such cases to be canonical instances of inductive inference, they supply the generalizing premise which Gassendi takes to be the mark of demonstrative, *a priori* reasoning—or non-deductive—syllogism.<sup>50</sup> And so he understands those cases as ‘probabilistic’ deductive reasoning which incorporates complete enumerations—where it is perhaps the key ‘probabilistic’ feature of such cases that the enumeration is truly tendered as complete.

### iii. ‘Probabilist’ Reasoning and Demonstrative Scientific Method

The suggestion that reasoning is ‘probabilistic’ if it is deductivist in form and its premises have contingent truth-values yields a dramatic result for Gassendi’s picture of scientific method, namely, that all our empirical claims are probable at best. After all, we base all reasoning to empirical claims on contingent premises, at least in the context of discovery where, whether we pursue resolution or composition steps, our assumptions are at least partly derived from experience.<sup>51</sup> One may find this result curious because it seems inconsistent with the goal of lending surety to scientific reasoning—the ostensible motivation for a *regressus* method. But there is nothing troubling about this result for Gassendi, whose general theory of empirical knowledge, we have seen, includes the notion that there is *nothing* we know about the world with certainty. There is also the echo here, in typical Gassendist fashion, of the ancient skeptical worry that we can know

<sup>49</sup> O I 118b; *IL* Book 3 § XIX, 150–151.

<sup>50</sup> O I 116b; *IL* Book 3 § XVI, 145. This categorization has it that, whereas all induction is demonstration, much demonstration consists in deduction.

<sup>51</sup> The only *non-probabilistic* deductivist inferences—because they are the only ones whose premises Gassendi views as not derived from experience—are those concerning canonical theology and cosmology.

nothing on the basis of syllogism on the grounds that we have no viable reason for accepting the initial premises as true. For his part, Gassendi rejects the Skeptic's view that warranted beliefs entail certainty about those beliefs, and so he can accept that such probabilistic empirical judgments may be warranted even as accompanied by residual doubt. Overall, though, like Glanvill, Mersenne, and other early moderns influenced by skeptical thought, Gassendi too tailors his method to ancient caveats regarding knowledge from the senses. Not surprisingly, he insists that reasoning employed in our exploration of the world is 'probabilistic' (in his sense of the term) if it is based on contingent premises. This is not controversial, since such reasoning generally is based on contingent premises. What *is* controversial or, minimally, quite unusual, is holding this view and all the while taking scientific method to be, in the main, a *deductivist* enterprise.

Other prominent seventeenth century writers on method avoid this sort of controversy by characterizing empirical reasoning as either inductive or else 'classically' deductive; cartesian method is classically deductivist, for example, whereas Baconian method is squarely inductivist. Indeed, Bacon expressly rules out syllogism—by which he means deductivist inference—as a model of scientific reasoning. He suggests there is an unacceptably high risk that 'notions', or the concepts underlying the words of a syllogism's propositions, represent the data of experience in inaccurate or overly-general ways. The classic defense of syllogistic method in scientific reasoning—which recurs in Gassendi's *Institutio Logica*—is that it provides a structurally secure inferential framework, and thereby sufficient warrant, for our empirical claims. In response to such a defense, Bacon points out that this structural strength can never guarantee such claims without directly appealing to our surest ideas, which concern the particulars of experiential data. Yet all such deductivist reasoning is founded on rash generalization, and so he concludes, "our only hope therefore lies in a true induction."<sup>52</sup>

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<sup>52</sup> "...if the notions themselves (which is the root of the matter) are confused and over-hastily abstracted from the facts, there can be no firmness in the superstructure. . . . (NO I xiv). Bacon also differs from Gassendi in that he advances an eliminative model of induction, not an enumerative one; q.v. recent commentary by Stephen Gaukroger, *Francis Bacon and the Transformation of Early-Modern Philosophy* (Cambridge; New York: Cambridge University Press, 2001), esp. 138–153; Peter Urbach, *Francis Bacon's Philosophy of Science* (La Salle, Illinois: Open Court, 1987),

Descartes, for his part, thinks deductivist inference is the premier mode of scientific reasoning, and induction in his view (in the *Regulae*) merely helps us attain those generalizations which serve as the starting points of our deductions. Thus he agrees with Gassendi that the deductions of scientific reasoning are based on premises we ground in experience, though he dismisses the idea that this makes the deductions probable in any fashion.<sup>53</sup> After all, we come to those premises on the basis of intuitions concerning such experience—about which we may be certain.<sup>54</sup> For Descartes no more than for Bacon, then, could it make sense to suggest scientific reasoning proceeds by deductive inferences which we do not even *expect* to guarantee the certainty of our claims.

Gassendi's chief insight in the context of these contemporaries is that *nothing* guarantees that our empirical claims are certain—not even the inferential structure of valid syllogism. This is because the aim of scientific reasoning is not preservation of truth (for example, across the premises and conclusion of a syllogism) but establishing credible claims about the world on the basis of other such claims we already believe, though we are not certain of them. This insight is underscored in Gassendi's 'modern' concept of probability, at least as concerns the degrees-of-belief concept: We make judgments about claims based on such evidence in their support that is *direct* or without the benefit of intermediary testimony. Hence the strength of our

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esp. 26–30; and Antonio Pérez-Ramos, *Francis Bacon's Idea of Science and the Maker's Knowledge Tradition* (Oxford: The Clarendon Press, 1988).

<sup>53</sup> Nor does Descartes hold, as Gassendi does, that we can employ syllogism to model our reasoning in ways that produce scientific decision; q.v. AT X 406, AT VI 17; Stephen Gaukroger, *Cartesian Logic* (Oxford: Oxford University Press, 1989), chapter one. Descartes' appeal to a *regressus*-like model of reduction and composition steps (in the *Regulae*) is never by way of syllogistic reasoning, and features the completely distinctive goal of identifying the most basic and fundamental form of a scientific query, in order to reach an intuition that can be exploited to answer the initial query; q.v. AT X 379–381; Garber (1993), 86–91. It is, in short, a wholly different methodological project than that proposed by the ancient, renaissance, or early modern *regressus* theorists.

<sup>54</sup> Garber (1993, 90–91) proposes that in the *Regulae* these intuitions are supposed to be rooted in natural philosophy and guaranteed by the method itself, whereas later in on the *Principles*, they are supposed to reflect basic truths of metaphysics and their ultimate guarantor is God. Gary Hatfield has suggested that by the late 1630s, Descartes changes his mind and holds that the premises of empiricist deductions are not certain, and that evidence for this view is not only in the Correspondence (from 1637–38) but in the *Principles* as well; q.v. Hatfield, "Science, Certainty, and Descartes", *PSA 1988: Proceedings of the Biennial Meeting of the Philosophy of Science Association* 2 (1988), 249–62.

beliefs in those claims is a measure of the degree of our confidence, not in another person (as per their testimony) but in the evidence itself. What it means to say that our degree of belief in a given claim is less-than-whole is just that the direct evidence in its behalf is less-than-fully compelling and so fails to make us certain of that claim. So it is with any empirical claims we attain by valid syllogism. The evidence for the supporting premises is *never* fully compelling thus we can never be certain of them—nor, as a result, of the claims they support.

One consequence of Gassendi's view is this symmetry between inductive and deductive reasoning about empirical matters: in the former we lack certainty as to whether the conclusion follows from the premises; in the latter we lack certainty as to the truth of the premises themselves. In either case, it follows from our imperfect access to the way the world is, that the claims we infer by such reasoning cannot be known with certainty. While this symmetry is an apparent consequence of his view, he never proposes or acknowledges that such is the case. Indeed, though his picture of inductive reasoning (correctly) allows that we have insufficient information from the premises to be certain of our conclusions, Gassendi's stated, idiosyncratic view of 'probabilistic' inference characterizes only deductive reasoning. That he may not recognize at all this symmetry makes all the more impressive his recommendation that judging both sorts of empirical reasoning entails recognizing their lack of certainty. We gauge the content-wise strength of a given deductive argument by our degree of belief in its constituent premises, just as we do in inductive argument. The substantial difference is that in an inductive inference we automatically register with the content-wise strength, some measure as well of its structure-wise strength. This measure is the conditional probability of the conclusion given the premises.

While Gassendi anticipates many elements of a contemporary, if broad construal of probabilistic reasoning, he strays far afield of our received view given his suggestion that a syllogistic form special to deductive argument determines when we are looking at a piece of reasoning we can call 'probabilistic'. Yet his account contributes here, not to the history of informal (let alone formal) logic, but to the history of theories of empirical reasoning. In these *Canons* of his *Institutio Logica*, he identifies what it means to have and rely upon contingent propositions at the base of one's inferences about empirical matters. It is rather awkward that he limits his characterization

of ‘probabilistic’ argument to deductive inference. To his credit, though, he sees it is not a *formal* feature of valid syllogism that we cannot be sure of empirical or other contingent claims we might so infer. That lack of certainty is simply the limit of what any such deductive inference can deliver. This may be indeed shaky ground upon which to assert our empirical beliefs, just as the ancient skeptics warn. However, it is also the only grounds open to deductivists of a strong empiricist stripe—including Gassendi in his *regressus* methodological mode—upon which to build such claims about the world. Hence Gassendi accepts ‘probabilist’ deductive inference for the same reason he accepts inductive inference without the crucial generalization step. Each regularly produces results—that is, viable empirical beliefs—even in the absence of beliefs that would confer total probability upon the conclusions. Utility thus emerges as a motivation in his analysis of inference patterns, as it does more globally in his general views on method.<sup>55</sup> Likewise, some measure of utility shapes Gassendi’s *regressus* method relative to the distinctive epistemic contexts of science. It is, naturally, a wholly other question as to whether, and how, he finds the various pieces of this method useful in his own scientific practices and reports; I explore this issue in the next chapter.

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<sup>55</sup> Gassendi further holds that we impute to the consequences of our hypotheses just that degree of necessity we deem useful, as measured, for example, by the capacity of the hypothesis to connect and explain the available data; q.v. chapter six.



## CHAPTER FIVE

### THE *INSTITUTIO* METHOD IN PRACTICE: GASSENDI'S REPORT OF THE PASCALIAN EXPERIMENT

To what extent does Gassendi employ the method he proposes in the *Institutio Logica* in his own scientific practice? To help answer this question it is fruitful to examine one of his most considered experimental accounts—the analyses of the barometric and vacuum-related experiments of 1648.<sup>1</sup> It may be said that his scientific practice conforms to the method of the *Institutio* just in case those analyses meet two conditions. First, the schema of core reasoning must be plausible instances of Gassendi's 'probabilist' deductive brand of argument; and second, such accounts must comprise, at least loosely, resolution or composition steps performed to realize discovery tasks.

This much is a banal achievement, however, if the fit is so loose that these schemas also conform to methods that compete with Gassendi's model. More significantly, it turns out, the reasoning of these experimental accounts does not comfortably fit with, and runs orthogonal to, the prescribed method of the *Institutio*. In Gassendi's reconstruction of the Pascalian barometry experiment, a search for the middle term turns out to be an obscure exercise—there is no univocal way to reconstruct the reasoning that underlies each account in syllogistic form. An additional problem—already noted in chapter four—is the daunting, if not unfeasible, task of finding a judgment-realizing step corresponding to the discovery-realizing step (the latter

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<sup>1</sup> I refer to these experiments variably as 'hydrostatic', 'barometric', and 'pneumatic'; the first connoting the study of pressure and equilibrium among liquids, the second connoting the study of atmospheric pressure, and the third connoting the study of the pressure of gases, generally. In essence, these experiments contributed to our conceptions in all three domains—most clearly in barometry—as well as the question of whether there was void created experimentally.

I also use the terms 'vacuum' and 'void' interchangeably; one might fruitfully distinguish the two, as Andrew Pyle does, to separate out the concepts of 'place' as incorporeal reality (vacuum) and emptiness of all matter (void); q.v. Pyle, *Atomism and Its Critics: From Democritus to Newton* (Bristol: Thommes Press, 1995). I am not concerned here with the former sense, though it takes on greater importance in discussions of Gassendi's atomism, particularly as regards his proto-Newtonian concept of absolute space.

being the primary feature of these experimental accounts). Perhaps more importantly still, these experimental analyses highlight a central methodological question wholly unaddressed in the *Institutio*: what are the guidelines for hypothetical reasoning? Gassendi's vision of investigations of the world around us, as based on information from the senses, sits astride his strong reliance, in these and other scientific writings, on hypothetical assumptions for which we have no direct evidence from the senses. This raises the question of what proper role such assumptions may have in advancing empirical inquiry, and how we are to judge their merits and admissibility—which I explore in chapter six. In the present context, the pressing question is how Gassendi attempts to relate the Pascalian experiments in his particular deductivist terms. To grasp his approach, it is helpful to first understand the nature of, and background to, those experiments.

*Pascal's Experiments on Hydrostatics and the Void*

At several points in his writings Gassendi describes an experiment which he believes to demonstrate both the existence of a created void and the fundamental barometric principle that the height of a liquid column in a tube is directly related to the weight of, and thus the pressure exerted by, the surrounding atmosphere.<sup>2</sup> Though performed by Pascal's brother-in-law Florin Périer at Puy-de-Dôme, the experiment was first explained in print by Gassendi (and only subsequently by Pascal), who learned of the details from Périer through a witness to the experiments, one illustrious Monsieur Mosnier.<sup>3</sup>

The early modern background to this experiment begins with Galileo's speculation that a vacuum existing between particles exerts a cohesive force on matter.<sup>4</sup> This speculation generated great debate

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<sup>2</sup> *O* I 203b–216a; *AN* II, Appendix iii–x; and a letter to Bernier of August 6, 1652, which focuses primarily on the subsequent barometric experiments of Roberval (*O* VI 317b–319b; *T* 593–596).

<sup>3</sup> The question has been raised as to the exact identity of M. Mosnier—whether he was Claude Mosnier, canon of the local cathedral in Clermont, or else Pierre Mosnier, a doctor from Lyons with interests in the sciences and a passing acquaintance of Gassendi's; q.v. Sylvain Matton, "Gassendi, Mosnier, et la Grande Expérience du Puy de Dôme", in *Société Scientifique* (1994), 303–322.

<sup>4</sup> Prior Western speculations on the void are largely defined by the ancients—atomists, Stoics, Aristotle, and Hero of Alexandria; one principal theoretical obstacle



and experimental activity around two issues: the existence and nature of the void, and the relation of atmospheric weight to the maximum height of a column of liquid. The latter issue arose because Galileo allowed that such a column might be sustained by the vacuum's force whereas, in his view, the atmosphere did not have weight.<sup>5</sup> Following on the heels of Galileo's conjecture, Torricelli showed in 1644 that a column of liquid in a tube is sustained by the weight of the atmosphere external to the tube. In fashioning his experiment so that the mercury descending the tube left an apparently empty space at the top, Torricelli also exposed the possibility that a void or vacuum might be produced by such means. A debate on this possibility ensued—with a rash of related experiments<sup>6</sup>—and in 1647, Pascal published his *Expériences Touchant le Vide*, in which he relates his first variations on Torricelli's experiment and defends the proposal that the space above the mercury could be a vacuum, rather than rarified matter. Here he does not discuss Torricelli's suggestion that the pressure of the outside atmosphere is what supports the

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for many, following Aristotle, was a natural *horror vacui*, the suggestion that a void is simply not tolerable from a physical standpoint (such that attempts to create one in, for example, a container should result in the collapse of the container's walls). Debate over whether this is a true obstacle or representative of a conceptual confusion extends into early modern times, as I note below; q.v. Edward Grant, *Much Ado About Nothing: Theories of Space and Vacuum from the Middle Ages to the Scientific Revolution* (Cambridge; New York: Cambridge University Press, 1981), and Charles B. Schmitt, "Experimental Evidence For and Against a Void: The Sixteenth Century Arguments", *Isis* 58 (1967), 352–366. Schmitt notes that a number of late Renaissance authors for *and* against the void cited experimental evidence which indicated the rarefaction of air under experimental conditions. Anti-vacuists like Toletus or De Soto embraced such rarefaction as was produced—clearly limited in extent—as indicative of the absolute limit to the lowering of density, there being no possibility of removing a last volume of air. Vacuists like Telsio or Patrizi understood such rarefaction instead as a limited case of creating interparticulate void (Schmitt, *ibid.*, 362–363).

<sup>5</sup> Q.v. Lino Conti, "Galileo and the Ancient Dispute about the Weight of Air" in *Die Schwere der Luft in der Diskussion des 17. Jahrhunderts*, ed. Wim Klever (Wiesbaden: Harrassowitz, 1997), 9–30. Conti notes that Galileo's absolute rejection of the weight of air is in response to the Aristotelian view that air has relative weight. In its natural place (amidst other air), it is heavy; otherwise, it varies, according to the medium. As Conti notes, the Aristotelian commentators varied widely on precisely how this relative weight should be defined. Q.v. also Cornelis de Waard, *L'Expérience Barométrique, ses Antécédents et ses Explications* (Thouars: Imprimerie Nouvelle, 1936).

<sup>6</sup> Q.v. DeWaard (1936); René Dugas, *Mechanics in the Seventeenth Century, From the Scholastic Antecedents to Classical Thought* (Neuchatel: Éditions du Griffon; Paris: Dunod; and New York: Central Book Co., 1958); and Giancarlo Nonnoi, *Il Pelago d'aria: Galileo, Baliani, Beekman* (Rome: Bulzoni Editore, 1988).

mercury in the tube.<sup>7</sup> In September of 1648 Périer, at the behest of Pascal, performed the barometric experiment of measuring the height of the mercury in the tube at various heights of the Puy-de-Dôme, and shortly thereafter Pascal himself performed a similar experiment at the St. Jacques Tower in Paris.<sup>8</sup> Pascal took the results of these experiments as evidence for the hypothesis that a vacuum sits above the mercury and for Torricelli's explanation of the mercury's suspension by reference to the air's weight and pressure.<sup>9</sup> In this first experiment, the height of mercury in a tube sitting closed end-up in an open basin (also filled with mercury) is measured at various altitudes, with the result that the height of the mercury column varies inversely with the altitude of measurement. Thus the mercury in the tube—at a height of 29 inches at sea level—falls when the apparatus is brought to the summit of a mountain, and the upper part of the tube becomes apparently empty. An equilibrium is established,

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<sup>7</sup> Indeed, the initial discussion of Pascal's experiments generally focused on the void. Prior to the *Expériences*, Jacque Pierus published the anti-vacuumist *An detur vacuum in rerum natura* (1646) and Pierre Guiffart published *Discours du vide, sur les expériences de Monsieur Pascal et le traité de M. Pierus* (1647); afterwards, Father Estienne Noël responded by arguing the Aristotelian case against the existence of a vacuum (*Le plein du vuide ou Le corps, dont le vuide apparent des expériences nouvelles, est rempli*. Paris: J. Du Bray, 1648). Noël's account echoes Descartes's view, that while atmospheric weight is causally responsible for the mercury's height, the void plays no part in this story, as void is not possible to begin with.

Pascal's reply (letter of October 29, 1647; q.v. *Les Lettres de Blaise Pascal: Accompagnées de Lettres de ses Correspondants Publiées*, ed. Maurice Beaufreton, Sixth edition (Paris: G. Crès, 1922), 15–33) is intriguing as a piece of his methodological views—here he offers an account of hypothesis acceptance that in part anticipates Karl Popper's. Whereas Noël proposes that the apparently empty space is subtle matter, Pascal rejects the notion that Noël has demonstrated a hypothesis to this effect. Evidence may disconfirm such a hypothesis, just in case the evidence runs counter to any phenomena to which the hypothesis commits us. It is not possible, though, for evidence to definitively confirm this or any other hypothesis:

... sometimes one concludes an absurdity to be manifest from its negation, and then the hypothesis is true and constant; or one concludes an absurdity to be manifest from its assertion, and in this instance the hypothesis is held to be false. And when one still cannot derive from an absurdity its negation or affirmation, the hypothesis remains doubtful—so that, to show that an hypothesis is evident, it is not enough that all the phenomena follow from it. Rather, if something follows that is contrary to only one of the phenomena, that is enough to ensure its falseness. (25–26)

<sup>8</sup> Two recent accounts of Pascal's relation to the Puy-de-Dôme experiment are: Daniel C. Fouke, "Pascal's Physics", 75–101, in Nicholas Hammond (ed.), *The Cambridge Companion to Pascal* (Cambridge: Cambridge University Press, 2003), and Mazauric (1998).

<sup>9</sup> Blaise Pascal, *Récit de la Grande Expérience de l'Équilibre des liqueurs* (1648).

and any shift in the altitude will produce a inversely-corresponding shift in the height of the mercury.

The questions arise as to how we can explain this inverse relationship, and what if anything is in the space above the mercury. Pascal, in his posthumous *Traité de l'Équilibre des Liqueurs et de la Pesanteur de la Masse de l'Air* (1663),<sup>10</sup> suggests the relation between the mercury and the surrounding atmosphere is such that, as one ascends with the tube the air thins, so the surrounding atmospheric weight decreases—with the result that the mercury falls. All other things being equal, the greater the weight of the surrounding atmosphere, the higher the mercury will climb. Further, he interprets the empty space above the mercury as vacuum, on the grounds that nothing else could have come to take the mercury's place as it falls. But that interpretation appears in print nearly a decade and a half following Gassendi's account—one year after the Puy-de-Dôme experiment—in an appendix to his *Animadversiones in decimum librum Diogenis Laertii* (1649). The *Animadversiones* account is largely recapitulated in the *Physics* of the *Syntagma Philosophicum* (1658)—together with his earlier insights regarding Pascal's Rouen experiments (initially penned by Gassendi in his *De nupero circa inane coacervatum* of April, 1647) and his report on his own barometry experiment in 1650 at Toulon, discussed in a letter to Bernier.<sup>11</sup> Since he had close access to Pascal's work through Périer, it is not surprising to find that Gassendi anticipates Pascal's central points.<sup>12</sup>

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<sup>10</sup> Blaise Pascal, *Traité de l'équilibre des liqueurs et de la pesanteur de la masse de l'air contenant l'explication des causes de divers effets de la nature qui n'avoient pas esté bien connus jusques ici, & particulièrement de ceux que l'on avoit attribuez à l'horreur du vuide* (Paris: chez Guillaume Desprez, 1663). Although the *Traités* were written as early as 1654, even the manuscripts would have been unavailable at the time Gassendi argues for his similar interpretation of the barometry experiments.

<sup>11</sup> August 6, 1652, *O* VI 317b–319b; *T* 593–596.

<sup>12</sup> This point was first emphasized in modern commentary by Bernard Rochot; q.v. “Comment Gassendi Interprétait l'Expérience du Puy-de-Dôme,” *Revue d'Histoire des Sciences* 16 (1963), 73–74. As Koyré and Massignat have noted, Gassendi's accounts even surpass those of Pascal's *Récit* and *Traité* in establishing a concept of (a) the compressibility of air as a basis for (b) the elastic pressure of air; q.v. Alexandre Koyré, *Metaphysics and Measurement* (London: Chapman and Hall, 1968) and Corrinne Massignat, “Gassendi et l'Élasticité de l'Air: Une Étape entre Pascal et la Loi de Boyle-Mariotte,” *Revue d'Histoire des Sciences* 53 (2000) 2, 179–203. The compressibility concept is discussed in the second *Traité* but never connected to the elasticity of air. The elasticity concept is missing altogether in Torricelli's analysis, and though Roberval articulates such a concept on the basis of his 1648 carp bladder experiment (described by Gassendi in his letter to Bernier), it is not expressed in

*Gassendi's Accounts*

As is typical for the early modern discussion in this domain, the *Syntagma* and *Animadversiones* accounts weave together assessments of barometric results and production of a vacuum. These accounts give greater weight, however, to the vacuum demonstration than is characteristic of much of the contemporary literature. This experimental possibility excited Gassendi as potential vindication of the Epicurean proposal of a void constituting the container in which atoms move and interact, and occupying the space between atoms. Indeed, one striking facet of Gassendi's analysis—especially given his global empiricism—is his suggestion that only if there is void can we account for the compressibility of air in the tube, which in turn is reflective of the variable barometric pressure with elevation. First, he indicates that the infilling of interparticulate void allows the air's compression, which augmented density creates pressure on the mercury in the tube:

... sometimes there is no place where the air is situated without losing its normal volume; and ... sometimes the particles from which the air is constituted come to be applied, one against the other, in such a way that they occupy part of the small interstitial voids that separate them. Thus the mass of air, becoming more dense and tight, is reduced to the least space—but that would not happen without a considerable amount of violence ... such seems justly the cause for which the pressure of mercury held in the tube is exerted on the mercury diffused on the bottom [of the apparatus], in such a way that the air that weighs above [in the tube] is pressed higher by this diffuse mercury.<sup>13</sup>

Next, he suggests that the degree of compressibility for the air in the tube is a function of the atmospheric pressure on the mercury in the tube which, directly proportional to the weight of the air in the surrounding environment, accordingly varies by altitude. He writes:

But it does not follow that the force of *any* mass, from *any* height of mercury, is of a nature to constrain the air to concentrate, so to speak, on itself (that is, to make its particles penetrate the little interstitial

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mature, quantified form until Boyle and Mariotte. I explore these conceptual advances below.

<sup>13</sup> *AN* II, Appendix, v–vi.

voids with greater strength) and make it thereby cede a little place. In reality, the necessary force or, if you like, weight, is that of a mass or height (of mercury) that is typically in the lower regions of two feet, plus about three inches. That is, the air with weight in the surrounding area is found, by the effect of the propagation of weight transmitted from the surface of the atmosphere, in such a state of compression of its own parts, that, the mercury being found at a lower altitude, the air exerts a stronger pressure; and at a more elevated altitude, a weaker pressure. Finally the altitude remaining the same, it equals the thrust of the mercury, and is equivalent to it in weight, or makes it equilibrrious.<sup>14</sup>

This last suggestion, that the weight and pressure of air are proportional—when coupled with the earlier suggestion that the air’s density and resistance to the mercury are proportional—marks great progress in our understanding of the barometric phenomena.<sup>15</sup> And as we will shortly see, this thread of analysis merits examination in its own right as a chain of explanatory reasoning. Yet the analysis is further noteworthy still, in proposing that the apparatus used in the experiment constitutes an instrumental milieu in which it is demonstrated that a vacuum must exist or else the compressibility of air said to occur would not take place. This thinking broadly matches Pascal’s own general interest in experimentally demonstrating the void, and anticipates the reasoning underlying subsequent experiments designed to directly demonstrate the existence of the vacuum. Such pneumatics experiments, including notably those of Guericke and Boyle, constitute a significant early modern chapter in the long tradition in the laboratory creation of physical entities or, in the case of the void, the lack thereof.<sup>16</sup>

<sup>14</sup> *AN* II, Appendix, v–vi (italics added).

<sup>15</sup> Massignat (2000, 189–190) suggests that, while a more rigorous formulation of  $p = v/t$  (that is,  $pv = k$ ) awaits Boyle and Mariotte, the seeds of that proportionality appear here in Gassendi’s discussion of the Pascalian experiment. In short, the variable height of the mercury column—or what amounts to the equilibrium of the air and mercury columns—results from the weight and resistance of air, and its elastic exertion of pressure. Another anticipation of this formulation was provided by Beeckman who, as early as 1626, identified a relationship between the pressure and volume of air—though in his scheme the rate of pressure growth outpaced the rate of volume loss; q.v. Cornelis De Waard (ed.), *Journal tenu par Isaac Beeckman de 1604 à 1634* (The Hague: Martinus Nijhoff, 1939–1953).

<sup>16</sup> Q.v. Steven Shapin & Simon Schaffer, *Leviathan and the Air-Pump. Hobbes, Boyle, and the Experimental Life* (Princeton: Princeton University Press, 1985), and Klever (1997) for discussion of the early modern developments in experimental creation of the vacuum.

*Void*

Opinions among early modern writers varied, though, as to whether the pneumatics experiments of the late 1640s demonstrated the existence of void—or whether, indeed, void could be demonstrated at all. In the anti-vacuist camp, a number of late scholastics, Jesuit writers, and other natural philosophers—well into the seventeenth century—proposed alternate accounts of these experiments, in order to satisfy the Aristotelian suggestion that ‘nature abhors a vacuum’.<sup>17</sup> Descartes and Hobbes constitute another camp, promoting a straightforwardly plenist view that subtle matter fills all interstitial spaces and would therefore fill in any such spaces that we could create, as for example, the space over the mercury.<sup>18</sup> In response, it is open

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<sup>17</sup> Among late scholastic opponents of the void, we find Père Noël (of the polemic with Pascal); among Jesuit writers, we find Paolo Casati (*Vacuum proscriptum*, Genoa, 1649), Gaspar Schott (*Mechanica hydraulica-pneumatica*, 1657), and Athanasius Kircher (*Musurgia universalis*, 1650). Approaching the issue from a more mechanist orientation, Roberval agreed that no vacuum was created, after all, in these experiments—only rarefaction of the air (although vacuum remained possible in principle). He recommended that the height of mercury be explained by appealing to *horror vacui* as an attractive force drawing the mercury upward. As the air in the space above is more rarefied, the mercury climbs; q.v. letters of Jacqueline Pascal to Gilberte Perrier (September 25, 1647, *MC XV* 447), Roberval, *De Vacuo Narratio* (1647) in Pascal, *OC II* 21–35, and Roberval, *Second Narration sur le Vide* (1648) in Pascal, *OC II* 310–410; also Sophie Roux, “Descartes Atomiste?,” *Atomismo e Continuo nel XVII Secolo*, ed. Egidio Festa & Romano Gatto (Naples: Vivarium, 2000), 211–274, esp. 243; and Noel Malcolm, *Aspects of Hobbes* (Oxford: Oxford University Press, 2003), 193–194.

<sup>18</sup> Hobbes (*Problemata de vacuo* (*Seven Philosophical Problems*), 1662) in his account embraces the Aristotelian argument that the passage of light through the empty space at the top of the tube shows that there is a medium in that space, as is required for light’s transmission. Hobbes comes to this plenists’ account, Malcolm (2003) suggests, in virtue of rejecting the notion of rarefaction—on the grounds that any given amount of matter requires constant volume; q.v. Malcolm (2003), 195; *De Corpore XXX* 1; *Six Lessons* 14, *EW VII* 224–225. Descartes, for his part, assimilates the experimental results directly into his previous views on matter, claiming that the 1648 experiment demonstrated core principles in that regard. Yet he does not specify which principles, and commentators differ on the issue. Daniel Garber maintains that the principle Descartes took to be affirmed is that there is no void, whereas Sophie Roux suggests that the relevant cartesian principle is that air has weight, which is causally responsible for the mercury’s height; q.v. Garber, *Descartes’s Metaphysical Physics* (Chicago: University of Chicago Press, 1994), 139–141; Roux (2000), 245–247. The two interpretations are, in any case, clearly related, as Descartes’ mechanical plenism must account for phenomena like the variable height of the mercury without appealing to forces that impel, which he takes to be ‘occult’. His solution—the basis as well for a distinctive barometric experiment of his own design—is that the gravity of the air particles brings about simple displacement of the mercury particles; q.v. John Cottingham, “Air, Gravity, and Cartesian Physics”, in Klever (1997), 31–45, esp. 42–43; *AT III* 484.

to proponents of the vacuum (including Pascal and Gassendi) to suggest how the void can occur despite this apparent abhorrence, or why theories of subtle matter do not block appeals to the void. Gassendi's approach is to tie together these two responses. The void can occur with subtle matter present, because the void in question sits in the interstices of subtle matter. As for the apparent abhorrence, the void is *not* spontaneously created, and matter typically fills the interstices if possible. What makes this possible, though, is that there is void to fill.

In particular, Gassendi contends, the void at the top of the tube—which he conceives of as ‘accumulated’ or homogeneous vacuum—can exist because it is actually a collection of discrete packets, lying between and around subtle matter remaining in the space above the mercury. In the *Syntagma* discussion, he proposes that, while this space may contain particles of some kinds of matter—such that any void there is interparticulate—the space contains no air. For air to be in that space, there would have to be an entry point for the air to flow in. Compare, he says, a container of water where there is no opening. If we seal a container of water with fish living in it, the fish will suffocate and die. But fish breathe in the water, so their death after we seal the container means that no air enters after the sealing.<sup>19</sup> By analogy, he reasons, there can be no air in a container of mercury unless there is an opening. But in this experiment, there is no opening at the top of the tube and so there is no air on top of the mercury column within. And since there is no air above the mercury, the apparently empty space must be largely void.<sup>20</sup> There are at least two problems here. First, the analogy is unfortunate, for in a sealed container of water there can be air, though perhaps not enough oxygen for fish to breathe; likewise there can be air, in small parts, in or above the mercury in a sealed tube. Second, a lack of air in that space does not rule out the ubiquitous presence of ‘subtle’ matter.

Indeed, Gassendi recognizes this second problem and embraces the possibility that there can be several types of matter in the apparently empty space, all the while allowing that much space may be occupied by interparticulate void. Corpuscles of light, heat, and cold, as well as ‘magnetism’ and ‘gravity’ particles, may all pass through

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<sup>19</sup> O I 205b–206a; q.v. Osler (1994, 187).

<sup>20</sup> O I 206 a.

and remain inside the glass of the tube, even if the tube does not permit air particles to pass (although he does not say why this last category is ruled out; perhaps it is because of their size). What appears to us as a thorough void, then, is rather an interparticulate void where the particles within and throughout are few and far between;<sup>21</sup> an interparticulate void outside the tube would be much more densely populated by particles.<sup>22</sup> We know there is some void in the space inside the tube because, if there were not, then the particles of matter could not pass through the tube—here Gassendi follows Epicurus’s reasoning that, since matter is impenetrable, only the existence of the void explains motion.<sup>23</sup> However, Gassendi claims, we also know this interparticulate void takes up a greater proportion of the space above the mercury than a comparable apparently empty space outside the tube, given that the total matter within it is, for lack of air, more attenuated than that without.<sup>24</sup>

### *Barometric Phenomena*

On the other side of the hydrostatic experiments, Gassendi anticipates Pascal’s suggestion (1654/1663) that the mercury in the tube is pushed upward to the degree the mercury in the basin is subjected

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<sup>21</sup> Lucretius offers an early Epicurean argument for interparticulate void, appealing to our ability to explain the relationship of density in a given volume to its weight (*RN* I. 258–265).

<sup>22</sup> *O* I 206 a–b; conversely, a region inside a container with yet greater pressure would force the creation of yet larger void spaces; q.v. *O* I 196b–197a, Detel (1974), 204. Other members of the Mersenne circle also recognized that, given a materialist account of light, as light passes through the apparently empty space above the mercury, there was perforce some matter in that space. This raised the concern that, if that space could admit of *some* matter, then in principle it could be *entirely* filled with matter (q.v. letters from J.A. LeTenneur to Mersenne (January 16, 1648, *MC* XVI 60), and from Thibaut to Mersenne (April 5, 1648, *MC* XVI 216); Roux (2000), 242–243). Here Gassendi’s notion of interparticulate void helps avoid a slide into plenism.

<sup>23</sup> The primary Epicurean argument has roots in the Eleatics (primarily Leucippus) and is better articulated by Lucretius (*RN* I. 335–45) than by Epicurus himself (q.v. *Her* 39–40). Aristotle rejects the appeal to motion by objecting that mere displacement of bodies would allow for motion, without any need to postulate the void (*Physics* 214a 29–32); as Pyle (1995, 51) and Asmis (1984, 241) have noted, Aristotle thus anticipates Descartes’ plenist reasoning. In turn, Lucretius responds to Aristotle, suggesting that displacement alone fails to explain how bodies *commence* any motion (*RN* I. 370–383; Pyle 1995, 66).

<sup>24</sup> *O* I 205b–206a.



to downward pressure—which increases as the elevation diminishes. The lower the elevation, he proposes, the larger the quantity of air in the surrounding atmosphere which hangs over the mercury, and as this quantity rises, so does the downward pressure of the surrounding air—in its component parts, and thus as a whole. This rise in pressure is a result of a rise in the net gravity of the atmospheric air. Gassendi contends that gravity works through chains of special corpuscles that attach themselves to bodies, which are then pulled down by those chains to the Earth's surface. As these gravity-chains pull air particles down towards the Earth, the weight of particles from any higher climb adds to the downward pull on any particles below, with the result that a lower particle of air “. . . possesses, other than that which is its own, the gravity added from all parts situated above it”.<sup>25</sup> A further consequence of this cumulative gravitational pull is that the pressure of air particles against each other increases, so that they push their way into the interparticulate void and their density increases, too. This heightened density increases the resistance of the atmospheric air, hence decreases the ability of the mercury in the basin to rise—leaving the mercury in the tube suspended at a relatively higher level.<sup>26</sup>

In his attempt to spell out the mechanical underpinnings of these various relations, Gassendi offers a microphysical account of the phenomena reported in Pascal's experiment. Towards this end, he posits the kinds of impetuses and resulting motions of particles which, he proposes, will vary with altitude given the specified conditions. On the basis of this account, he argues that a void, together with the right sorts of corpuscular interactions, yields the instrumental variance produced in the experiment. His reasoning may be outlined as follows:

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<sup>25</sup> *AN* II, Appendix, vi.

<sup>26</sup> *AN* II, Appendix, vi. Gassendi stresses that the specific degree of force exerted on the instrument is a function of local conditions, which in this case consists in the particular mass of air immediately above and surrounding the tube. Thus, whereas the vast surrounding mass of air allows for the overall constancy of forces exerted upon the mercury at any given location of similar elevation, the mass of just the single column of air, suspended directly above the immediate area of the tube, accounts for the particular degree of force exerted on that tube and the mercury within. By way of analogy to this explanatory appeal to local mass, Gassendi accounts for the variable strength of a water jet from a hole in a container by suggesting that strength is a function of the pressure of a water column directly above the hole.

- (1) A necessary condition for particle motion is the existence of disseminated (interparticulate) or accumulated void—and since there is motion, there is void;<sup>27</sup> and
- (2) A sufficient condition for particle motion is the combination of impetuses brought about by corpuscular interactions which, in the aggregate, produces a ‘common action’ that makes bodies of liquids or air flow in a given direction (though, individually, each impetus may bear minimal influence on the trajectory of the bodies those particles compose);<sup>28</sup>
- (3) Thus there is even motion in the void when particles are contained in a circumscribed area with no visible empty space: under sufficient pressure the particles move closer together by entering disseminated void, and so become more densely packed.<sup>29</sup>
- (4) One instance of this kind of motion occurs in the Puy-de-Dôme experiment, where the interaction of atmospheric particles exerts a pressure causing a proportionately varying motion of the mercury; and consequently, of the air above the mercury. At low elevation, this pressure forces the mercury to rise such that air and dust particles above the mercury in the tube move into the disseminated

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<sup>27</sup> “. . . absolutely nothing else comes in place of the body that has been dispersed—in the way it is possible relative to the interior of a heap of wheat to conceive of a big enough space in which there would be no grain, as for example if these grains were pushed back in all directions.” In a different vein, Gassendi also proposes that “. . . nature having formed from very fluid bodies like water and air, this fluidity does not allow any particle of these bodies to be easily dispersed from the place they occupy without others, pushed back from their own position, coming to that place. And whereas this fluidity by itself belongs to the bodies in question, it is not by accident that they do not permit this place to remain empty, in the same way that if my hand moves around inside the interior of a heap of wheat, the grains come flowing by themselves to the place where my hand left, and it is only by accident that they do not leave the place of those grains empty.” *AN* II, Appendix, iv. Here Gassendi appeals to the existence of void as a necessary condition for explaining the phenomena, classically associated with *horror vacui*, of fluid displacement (where volume A always displaces volume B when B is removed rather than a void taking B’s place). It is precisely because void exists, Gassendi argues, that there is space where the first volume stood and which can be newly occupied by the second volume; that no void is present there when the first volume leaves is merely accidental, and in the case of the interparticulate void, not even true.

<sup>28</sup> “. . . the cause of this fluidity is the gravity which, inherent in all terrestrial bodies and in particular in air itself, appears to be constituted by nothing other than a mass of corpuscles continuously expelled from earth, water, and bodies formed by mixture—corpuscles that nevertheless all together tend towards the terrestrial globe from which they are drawn. This is in virtue of a quality which is their own, or by attraction of the earth itself; and in such a way that, in the whole region where they encircle the earth (which is called atmosphere) their common action—that is, their gravity or weight—is exercised, from which the influence is so strong that a body falls down all the more, rather from the surface of the atmosphere towards the earth.” *AN* II, Appendix, iv.

<sup>29</sup> *AN* II, Appendix, v; q.v. note 13, above.

void; at high elevation, the pressure drops and the situation is reversed.<sup>30</sup>

- (5) Hence in this experiment, the presence of a disseminated void at the top of the instrument, together with the interactions of atmospheric particles, accounts for the greater density of air and the rise in the mercury in the experimental device, at lower elevations—and for the reverse of those effects at higher elevations.<sup>31</sup>

The argument for the first point here—the necessity of the void for particle motion—alters the grounds for the ancient suggestion that we need the void to explain motion, but similarly begs the question. In Gassendi's version of the story, void must exist since it is possible to concentrate all matter found in a given space such that, with the matter pushed to one side, the resulting cavity would be perforce wholly empty. Hence empty space can be shifted around with varying distributions of matter—the implication being that atoms are unfixedly distributed in the medium of a void. As with the ancient account, the conclusion here is that emptiness is what allows matter to move around to begin with. And like the ancient account, Gassendi's proposal effectively *stipulates* that there is no plenum, in the sense that there are voids in which bodies can shift around.<sup>32</sup> This is a difficulty for ancient and modern alike, though it is one

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<sup>30</sup> “. . . after pushing the piston of a syringe up to its orifice, if when stopping up this orifice we draw out the piston from the syringe—and thus push behind it the air which can no longer slip into the space the piston left in the interior—this could not be done without an energetic effort; and similarly when we compress air in a pneumatic cannon, a certain effort is required. . . . [S]uch seems justly the cause for which the pressure of mercury held in the tube is exerted on the mercury diffused on the bottom [of the apparatus], in such a way that the air that weighs above [in the tube] is pressed higher by this diffused mercury.” *AN* II, Appendix, v–vi; q.v. note 14, above.

<sup>31</sup> “. . . in a place of lower elevation there is a larger quantity of air extended over it and from the upper part of the atmosphere; the common effort of the component parts is thus stronger, and the gravity is stronger (from the fact that each lower part possesses, other than that which is its own, the gravity added from all parts situated above it), and also consequently the pressure of the parts one against the other, the squeezing of one against the other, and their mutual contact through the little empty spaces, are all greater; from which follows a great density, a greater difficulty for the subsequent intrusion of new parts. And thus it is that there is in this case necessarily a greater resistance to the flowing of the mercury, and that to create an equilibrium, there must be a greater quantity, or greater height of mercury in a low place than in a high place; and of the sort, the mercury in the tube stops higher in a low place, lower in a high place.” *AN* II, Appendix, vi.

<sup>32</sup> On other significant ancient arguments for and against the void, q.v. Pyle's discussion of the Eleatics and the Aristotelian responses (1995, 41–64).

Gassendi thinks he can get around it by offering a variety of empirical arguments, all of which suggest that void is required to explain appearances of moving objects. Such reasoning may be thought to simply recapitulate the ancient argument and thus rely once again on the presumption that the plenist is wrong.<sup>33</sup> Whether the argument for the void is actually advanced any by couching it in such empiricist terms depends on the strength of Gassendi's particular model for explanation of this form—which I discuss in chapter thirteen.

The second point—the sufficiency of gravitational action, per his corpuscularian picture of particle motion—rests a little more securely on independent physical claims. Gassendi contends that the impetuses, or pulling and pushing, of macro-sized bodies have their ultimate causes in the gravity characteristic of and inherent to their constituent micro-sized parts. This is consistent with his view that *all* candidates for action-at-a-distance are best explained by understanding any such impetus (as well as any *vis* (force) associated with supra-atomic bodies) as the product of corpuscular interactions.<sup>34</sup> In this way, a key element of Gassendi's general matter theory—quite apart from an anti-plenism *per se*—helps establish a vacuist interpretation of the Pascalian experiment.

This suggestion—that corpuscular interactions yield impetuses causing macro-level motion—allows that what seems like uniform motion from a macro-level perspective may well be the product of diverse, micro-level impetuses. In this vein, knowing only the direction in which particles move in the aggregate does not tell us what individual, underlying impetuses may bring about their motion (here we see an echo of his rejection of inherent directional tendencies of falling bodies, particularly in *De Motu* (O III 495a–b)). Gravity, for instance, may contribute to a set of impetuses, the combination of which causes particles to move in any given direction, and not just downwards. As an example of such combined impetuses, he cites the case where air rises from a container with an opening on top. We might expect the air from within to travel up and down with similar ease; instead, upward motion occurs regularly. This is because atmospheric air—subject to gravity and resulting downward pressure—

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<sup>33</sup> This appeal to the empirical evidence of motion is developed in early Epicurean thought by Philodemus (*De Signis* 8, 35–36; Asmis (1984), 209).

<sup>34</sup> I examine this view in chapters ten and eleven.

pushes down on the container and the enclosed air, with the initial result that the air within is pushed down. Yet that same depressed air then exerts an extraordinary pressure *back up* on those particles pushing it down (these are further air particles, from the outside), producing an ejection-like behavior that alone restores equilibrium. In this pulling-down action, gravity produces pressure, which in the end forces particles upward.<sup>35</sup> This combination of impetuses is possible due to a homogeneity of the corpuscular interactions contributing to what Gassendi thinks of as distinctive impetuses—for example, gravitational downward action or the lateral action of bodies traveling on a horizontal plane. If such interactions varied widely enough (for example, relative to the laws their behavior obey), the impetuses they bring about might not be capable of being aggregated, integrated, or reversed. The details here are sparse. The general picture, though, is clear enough: on the macro-level, a given impetus A acting alone may set particles in motion in one particular direction yet the combination of various impetuses, including A, may produce motions in any other direction.<sup>36</sup>

The third point is that such impetus may cause particles to ‘find’ a void that permits their motion, so that even when particles are constrained to a particularly dense region, they may become denser under pressure. In this way particles may remain in motion, though there is no apparent empty space for them to move through. In the sealed tube of the instrument used in the barometry experiment, for example, it seems to the naked eye that when the mercury rises in the tube there is less space at the top for the air particles to move around (than when the mercury was lower). If there was *no* place for the particles to go (without, quite impossibly, decreasing their minimal particulate volume) they would resist the pressure. But under

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<sup>35</sup> *AV* II, Appendix, v.

<sup>36</sup> The motivation for this view is likely peculiar to Gassendi’s corpuscular philosophy. He needs such an account to explain how individual, micro-level impetuses associated with specific corpuscles do not interfere with the macro-level behavior of what we observe as impetuses on the grand scale (as in the barometric experiments). By proposing that impetuses in combination can bring about motions in variable directions (not tied to, for example, the downward motion created by gravity) Gassendi allows that the motion of macro-level bodies or aggregate liquids or gases is brought about by impetuses with micro-level causes, though not necessarily by any single such impetus as may correspond to what is manifest in the experimental results.

sufficient pressure the particles move through or into empty space formerly between them, which results in bringing them closer together and making the air a denser gas. This requires great effort or energy, Gassendi suggests, since the air particles must ‘push into’ an interparticulate void that otherwise separates them.<sup>37</sup>

The fourth point is that the great effort required to generate this motion of air particles above the mercury in the tube is provided by the pressure that air propagates in the surrounding environment, from the atmosphere’s upper surface downward. As a result of the atmospheric pressure, the mercury spread in the basin pushes the tube’s mercury upward—and air particles in the space above move into the disseminated void. Hence, Gassendi concludes, the level of the tube’s mercury (and density of the air above it) is inversely related to the elevation of the apparatus *because those corpuscular interactions contributing to pressure on the tube’s mercury and air vary with altitude*. At lower altitudes, so great is the atmospheric pressure (and resistance of the basin’s contents to downward pressure of the tube’s contents) that the mercury is driven up toward the top of the tube, such that the air above becomes denser. But by bringing the tube to a higher altitude we decrease the atmospheric pressure and so the mercury falls.<sup>38</sup>

The significance of this experiment, as Gassendi and Pascal equally well indicate, is that there is an inverse variation of atmospheric pressure with elevation. But one inventive aspect of Gassendi’s account is that he tries to identify underlying, imperceptible physical conditions that generate the inverse relation of the mercury’s height in the apparatus with the elevation of the apparatus.<sup>39</sup> In so doing, he

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<sup>37</sup> An implication of Gassendi’s suggestion that great effort is required to push air particles into interparticulate void is this: something about this separating space was fitting to some ‘natural’ distribution of the air particles, so that only extraordinary force would condense them. This raises the question as to what a *natural* distribution of gaseous particles would be. That might well be a function of the height of the instrument above sea level, but then we still need an account of why a given atmospheric pressure yields its corresponding distribution of air particles. An even knottier question is why extraordinary force would be necessary to condense the particles if there is only empty space between them.

<sup>38</sup> As a concomitant effect the air atop the mercury becomes less dense and so the interparticulate void expands.

<sup>39</sup> As mentioned above (note 12), Koyré (1968, 128–129) highlights the novelty of Gassendi’s introduction of the elastic pressure of atmospheric air as the primary cause of the mercury column’s variable height. By contrast, Pascal explains the barometry experiments in purely hydrostatic terms, by reference to the balance

tells us not just what foundational physics supports the story of the mercury's rise and fall, but also, and as a result, precisely how we may relate the experimental data to the inverse variation for which it purports to give evidence. This is possible because Gassendi outlines (in whatever rudimentary or inaccurate terms) atomist underpinnings of the experimental behavior produced by the Pascalian instruments—as well as the broader phenomena that behavior represents.

*The experimental account and the method of the Institutio*

The merits of these foundational details—and so the strength of this experimental account—rely on the plausibility of his physical picture (q.v. chapters nine and ten). The question here, though, is whether his reasoning satisfies the method of the *Institutio Logica*. At a most general level, we would want to see that Gassendi's reasoning in his account of the Pascalian experiments is of a globally deductivist nature, in keeping with the pervasive form of reasoning detailed in the *Logic*. By this token, then, it counts as a shortcoming that his experimental account is not thoroughly deductivist, and is rather based, at least in part, on what Gassendi identifies in the *Institutio* view as inductive inference. A very general version of his reasoning for the void *can* be rendered as simple deductive syllogism: above the mercury there is an apparently empty space but no air, and wherever there is empty space but no air there is void, hence there is void above the mercury. The reasoning for his principal lemma also fits: there is no opening on the top of the tube, and without an opening no air can enter the container, hence there is no air on

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of the weights of atmospheric air on the one hand and the mercury column on the other. Hence for Koyré, Gassendi's atomism generally yields an elastic picture of gases (or at least air) and thereby leads to the realization that a proper account of the barometry experiments must go beyond pure hydrostatics. An amendment to Koyré's assessment is that Gassendi's account of the variable height of the mercury column depends critically not only on his characterization of atoms *per se* but on his positing the void. As Massignat points out, the compressibility concept requires thinking of two quantities (e.g. of air) as being equal in weight but not in volume. Thus, in promoting the void, Gassendi provides a microphysical explanation of the condensation and rarefaction phenomena that (given the atmospheric pressure) allow for an equilibrium between the air and mercury (2000, 180–181).

the top of the tube. Yet we may doubt a deductivist account is applicable in this instance: Gassendi's proposed grounds for thinking there can be no air above the mercury without an entry point—his analogy to the water container—is an instance, in his scheme, of argument by example, which he categorizes as a species of inductive reasoning. Gassendi, for his part, does not have these doubts, because he thinks his account of deductivist method *is* satisfied by any syllogism that supplies the requisite generalizing step—even if based on embedded nondeductive inference. It does not occur to him that arguments with such embedding might be better understood as nondeductivist at root. Nonetheless, there is a partial fit with the *Institutio* method, for we can at least say that his reasoning is 'probabilist', in his special sense, since his assumptions are empirically-derived and therefore contingent. Putting these two elements together, the claim of a void atop the mercury satisfies his notion of a 'probable' claim attained by deductive reasoning. Whether it should satisfy *our* notion of deductivism is, naturally, a further question.<sup>40</sup>

More significant still is how well Gassendi's account conforms to his version of a *regressus demonstrativus* method. One indication in this regard is his claim that our lack of sensory access to the underlying phenomena should not prevent us from understanding the causal story of this experiment. Rather, we gain insight into that story by way of conjecture from the apparent effects:

Our faculty of understanding and knowing is . . . made such that if we are incapable of grasping by a direct view the constituent elements of things, we can at least grasp some of their effects. And from there—after having succeeded at guessing (in some way) things concerning these elements apart from some of their effects—it is convenient to

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<sup>40</sup> This reliance on inductivism—which appears elsewhere in Gassendi's scientific reasoning as well—suggests that Detel (1974, 2001) is incorrect in proposing that Gassendi's method of choice is hypothetico-deductivism, at least in any unalloyed form (indeed, Detel argues that the Pascalian experimental accounts are paradigmatic examples of such method in play).

In this context, it also emerges that Detel is incorrect in proposing that Gassendi has an actual H-D method which contrasts with his merely theoretical interest in empiricism and allied forms of reasoning. As we have seen, Gassendi identifies deductivism as a globally form for reasoning, about empirical matters as well as anything else (indeed, just about all matters are empirical in his view)—and thinks this form can be pursued in empiricist fashion. His appeal to analogy and other means of inference by reference to data from the senses are examples of his attempts at such pursuit.



content ourselves with doing all we possibly can to accommodate to other effects those notions we form (whatever they are) about the preceding effects. This we do anytime we examine the causes of these effects, or ask how they are originally derived from their components.<sup>41</sup>

Thus, he proposes, we reason from the apparent lack of air atop the mercury to a putative cause, the existence of a void that results from mercury sealing the cavity:

In the present question, it is certain that if we were naturally endowed with a clairvoyance great enough to perceive the constitutive elements of mercury and air, we could without hesitation and with no previous reasoning say what is the true cause of the effect on what we examine. But as we are not thus endowed, what can we do other than conjecture at first, following other effects, and then assure that the natural constitution of these bodies is such that this effect, and not another, could result from it?<sup>42</sup>

‘Discovery’ by resolution (as the *regressus* method recommends) does not identify the *only* conceivable causes of the apparent effect. In this instance, such identification would require knowing the natural constitution of the causal elements, and for that we would need clairvoyance. Lacking such cognitive capacity, we instead ascertain (or ‘judge’, in *regressus* terminology) on the basis of an abductive move, that no other causal account will suffice.<sup>43</sup>

As with ‘discovery’ generally in this experiment, the resolution step should entail a search for the middle term. One might suppose that Gassendi understands the search in this case to consist in his effort to demonstrate, via the fish-container analogy, that there can be empty space and yet no air at the top of the tube. This much of his analysis conforms to the method of the *Institutio*. Yet nothing in his exposition *requires* the discovery method. Conjecturing about causes as based on their effects just as well suits other methods that do not entail searching for the middle term. Further, if Gassendi’s analysis is to count as a discovery, strictly speaking, it should be worrisome that the void is not really something he finds, after all, so much as postulates.

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<sup>41</sup> O I 207b.

<sup>42</sup> O I 207b.

<sup>43</sup> Here we see an instance of Gassendi appealing to inference to best explanation; in chapter thirteen, I propose that this is a significant form of inference for Gassendi, upon which he relies for his grand or ‘long’ argument on behalf of atomism as the matter theory of choice.

In any case, this experimental account conforms fully with the *Institutio* method only if there is a corresponding ‘judgment’ consisting of a composition step—reasoning from cause to effect—that is, reversing the resolution step. What is needed here is an inference from the causal claim that there is a void above the mercury to some claim of an effect pertinent to and confirming of the ‘discovery’, such as the suggestion that there is no air above the mercury *as a result of* the void. Perhaps this is Gassendi’s aim when he proposes that the existence of a void permits subtle matter in the cavity above the mercury to pass through the tube. But if we need to stipulate the void to explain how subtle matter can move through the tube, then he has reasoned again from effect to cause, and this will not count as the corresponding composition step. At any rate, that the void accounts for subtle matter does not provide confirming evidence for the claim that there is *no* air above the mercury; if anything, this suggests the opposite might be the case.

It cannot be surprising that Gassendi’s account of an experimental demonstration of the void fails to conform very closely to that method. Yet it is unsettling that the lack of conformity is so great. By way of comparison, Gassendi’s account of the level of mercury in the tube (per its elevation) conforms a bit better to the *Institutio* method, though only at such a broad granularity that either the method is not explanatorily useful, or else the experimental account is disappointingly underspecific.

Like the vacuist argument of his account, the atmospheric pressure argument relates a discovery task. Here, too, the assumptions are contingent and attained by induction, based on the iterative collection of data at various elevations. Hence the argument as a whole is again ‘probable’ though deductivist in Gassendi’s unusual sense (the deduction being characteristic of the overall structure of reasoning, inductively derived premises notwithstanding). But unlike the vacuist argument, his reasoning relative to the weight of air and height of the mercury runs from cause to effect—which counts in the *regressus* framework as a composition step.<sup>44</sup> There are in the end two causal stories, the first a microcosmic picture that underlies the

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<sup>44</sup> It is not clear whether the *regressus* method licenses this starting place. Presumably it is permissible, if at all, only if a corresponding resolution step can be extrapolated. As to whether that is possible in this instance, q.v. discussion below.

second. According to the first, microcosmic story, whenever there are impetuses that act on particles in a void (themselves the products of corpuscular actions or interactions), those particles are set in motion through the void.<sup>45</sup> According to the second, macrocosmic story, the right kinds of instruments and settings, together with the right combination of impetuses, produce motion in particular directions; if we vary these conditions, then the directions and extent of the motion will vary as well. Gassendi builds the second causal story on the principles and conditions described in the first story. It appears, then, that the atmospheric pressure account aims to say what kinds of effects we can expect to observe when we postulate particular imperceptible entities and phenomena as causal factors.

Difficulties with Gassendi's approach here abound. For one, he warns himself—in the context of the vacuist argument—that we lack access to imperceptible causes of these experimental results, and this warning apparently undermines any empirical warrant we might summon for his claims that the weight and compressibility of air arise from just such causes. More generally, he postulates rather than demonstrates the presence of those causal factors and one may wonder how such an account provides illumination, much less discovery.<sup>46</sup> While Gassendi addresses these difficulties (q.v. discussion below and chapter six), his proposed solution leads him astray of his prescribed *Institutio* method.

However, from the perspective of internal coherence (relative to the method and applications thereof), the first order of difficulty is the fit of Gassendi's reasoning to his *regressus* model. The challenge is to identify how this atmospheric pressure account might be understood as entailing the search for a middle term, and further, what in this instance might count as a corresponding resolution step, reasoning from effects to causes. This search begins with the identification of that middle term, and here arises the problem of determining which, among various candidate syllogisms, best provides that term.<sup>47</sup>

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<sup>45</sup> If the particles are already in motion—as Gassendi says is a constant feature of atoms—it is unclear as to whether they are supposed to *gain* motion, and how they might transfer it; q.v. chapter 10.

<sup>46</sup> Detel (1974, 206–207; cf. also (2001)) diagnoses this difficulty with Gassendi's reasoning as an *ad hoc* substitution of theoretical hypotheses for empirical data, towards the end of defeating experientially-rooted objections; this is compelling evidence, Detel suggests, that Gassendi is far from empiricist orthodoxy.

<sup>47</sup> This is a potential difficulty for the entire *regressus* tradition, from Aristotle

A variety of alternate reconstructions yields some crucial part of the reasoning in the atmospheric pressure account:

(A)

Whatever is in motion passes through the void, and  
 Whatever passes through the void is compelled by corpuscular interactions,  
*thus*  
 Whatever is in motion is compelled by corpuscular interactions;

(B)

The degree of atmospheric pressure exerted at any given elevation can  
 be measured by the downward pressure transmitted by constituent  
 atmospheric particles, and  
 Such downward pressure at any given elevation is the sum of pres-  
 sures transmitted by particles at all higher elevations,  
*thus*  
 The degree of atmospheric pressure exerted at any given elevation can  
 be measured by the sum of pressures transmitted by particles at all  
 higher elevations;

and

(C)

The experimental conditions of the Puy-de-Dôme trials—the fixed  
 instruments and settings, and varying elevations and atmospheric con-  
 ditions—yield a particular range of combined impetuses acting on the  
 mercury, and  
 Such a range of impetuses produces motion of the mercury within an  
 associated range of parameters,  
*thus*  
 As we vary the conditions, the directions and extent of the mercury's  
 motion varies as well.

This particular set of syllogisms alone provides three distinct middle terms—and yet other syllogisms modeling further elements of the reasoning in this account would provide more choices still. On the basis of the *Institutio* account—or anything else in Gassendi's corpus, we have no guidance as to how to choose from such alternative reconstructions, and so identify the middle term. Moreover, we cannot reconstruct the entire argument of the atmospheric pressure account in syllogistic form without either generating multiple syllogisms, hence multiple middle terms, of this sort. Alternatively, we

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onward. Whatever Gassendi's contributions to shaping an early modern version of this model of reasoning, he offers no novel means of avoiding that basic problem of the model.

can omit some key steps, simplifying—and undoubtedly not doing justice to—Gassendi’s construal of the experimental reasoning as a complex thread. As a consequence, we cannot clearly identify a single middle term that picks out a unique, germane discovery task of the experiment, and in this way we fail to satisfy the *regressus* model.

This failure can be assessed in two ways. First, it is possible to judge that the Puy-de-Dôme experiment as recounted by Gassendi features more than one discovery task, in which case the reasoning he employs in this account does not neatly fit the *regressus* model, at least in its canonical form. The other possibility is we judge that there is one unique, germane discovery task but nothing in the *regressus* model tells us which it should be. If we follow the first possibility, then this experimental account can be discounted as exemplary of Gassendi’s *Institutio* method. If we follow the second possibility, then the method turns out to be unsatisfactory, at least as a set of tools for modeling Gassendi’s reasoning in this instance. Yet this last point seems unlikely, or at a minimum, unwelcome: there is little question as to the centrality of the *Institutio* method for Gassendi. Several significant drafts of his logic were crafted before the final version appeared in the *Syntagma*.<sup>48</sup> Indeed, other strains of the *Institutio* method are mirrored elsewhere in Gassendi’s thought, including and especially his inductivism and reliance on evidence from signs (cf. chapters two and four). The first possibility, by contrast, offers the merit of suggesting that discovery tasks in some experiments may be sufficiently complex that we cannot single out one particular finding as the lone target of such investigations. Conceivably, some expanded, more intricate form of the *regressus* model might accommodate such complexity. A further question is whether it is satisfactory on the whole to not be able to specify a unique discovery task. This may be a fuzzy way to construct or account for experiments. On the other hand, it does not place constraints on thinking about experiments that the investigators may not themselves adopt. In a sense, Gassendi should have found such a lack of constraints to be an attractive result, for a similar freedom of interpretation allows his own experimental account to diverge from and expand upon that of the Puy-de-Dôme experimenters themselves. However attractive this interpretation, though, it is not possible to attribute it to Gassendi

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<sup>48</sup> Q.v. Jones (1981).

directly. He never identifies such consequences, much less such an extrapolation on the *regressus* model.

At all events, the atmospheric pressure account fits the *regressus* method all the more poorly if we try to identify the corresponding resolution step; having started with composition, the reverse process of resolution is a matter of bookkeeping—but essential to demonstrating that the *regressus* is complete in principle. Once again, the problem is that what constitutes the discovery in question is subject to interpretation, and dependent on the context of the experiment's description. In this instance, though, we cannot even know precisely what syllogism we need to 'reverse' in the resolution step, given that it was not possible in the composition step to identify a unique discovery task. Accordingly, it is not possible to realize the judgment task through resolution. Thus, were Gassendi to pursue such a judgment to show his reasoning best (if not uniquely) accounts for the data, he would be unable to specify how to do this, lacking knowledge of the terms of the requisite resolution step.

While these experimental accounts fail to neatly match the constraints of Gassendi's *Institutio* method, it is most striking that they exhibit important methodological aspects concerning which the *Institutio* is silent. As we have seen, one such aspect is the suggestion that investigators set out to find evidence for a *variety* of claims in a single experiment, or interpret such experimental results accordingly. Another is the central role of hypothetical reasoning: save for brief discussion of sign-based inference in Book IV, Gassendi says nothing about hypotheses in the *Institutio Logica*. In his atmospheric pressure account, though, he prominently introduces substantive assumptions about the kinds of causes there may be, deduces their effects, and then explains the data as effects of such causes. Thus, Gassendi assumes that only a corpuscularian-mechanical picture and an interparticulate void allow for the motion of bodies.<sup>49</sup> These are untroublesome assumptions, at least insofar as they are repeatedly stated, core elements of his

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<sup>49</sup> Although Gassendi assumes that the void alone accounts for the motion of particles, an ostensible aim of these accounts is to establish that the Pascalian experiment demonstrates that a void exists atop the mercury in the tube. These two claims may be usefully viewed as distinctive appeals to inference to the best explanation (cf. chapter thirteen). Thus: we best explain physical motion by postulating the existence of voids generally, and our best explanation of the specific cavity above the mercury (as containing a particular instance of void) relies on the experimental data we count as evidence for the barometric phenomena in question.

physical picture. Other assumptions, however, are never made explicit, perhaps because Gassendi takes them as peripheral to his physics. The account of how the apparatus indicates changes in atmospheric pressure, for example, supposes that collections of gas particles behave in ways relevantly similar to collections of other sorts of particles (like mercury) with respect to gravity or other forms of impetus and attraction.<sup>50</sup> In either case, though, the *Institutio* method does not give us guidelines for such reasoning from unproven assumptions or by hypotheses. We are not told, for instance, when it is appropriate to draw upon hypotheses in scientific reasoning, how to identify warranted hypotheses in such reasoning, or the nature or measure of evidence for hypotheses. These are, however, topics that Gassendi addresses elsewhere, and I next turn to his views on a method of hypothesis.

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<sup>50</sup> Gassendi makes a number of other important assumptions, including, for example, that there is a general continuity of environmental (hence experimental) conditions across elevations. He is at least obliquely aware of this in the context of his own barometric experiment of 1650, where he makes special note of the variance of the atmosphere's weight with its temperature and humidity (*O VI* 319a–b).





## CHAPTER SIX

### A METHOD OF HYPOTHESES AND HYPOTHETICAL REASONING

To examine critically a method of hypothesis and hypothetical reasoning in science, one issue to resolve at the outset is what counts as a hypothesis. From a most catholic perspective, there is a wide variety of things we take to constitute the hypothetical or conjectural part of science. In Gassendi's time, one might think of hypothetical entities like cartesian vortices, idealized phenomenal generalizations like the law of free fall, conjectural guides to research like the Ptolemaic picture of the heavens, data-synthesizing explanatory models like Harvey's picture of circulation, and predictive models such as Kepler's model of planetary orbits. These very different kinds of items share at least one feature: that we accept them 'on credit' with the promise that, later on, this acceptance may be further justified in some manner.

The point of this preliminary acceptance, according to one view with classical roots, is to be able to reason about and further our understanding of other phenomena for which we do have evidence, given the explanatory, inference-building, or exemplifying benefits (to name a few) of assuming such hypothetical items even though we lack satisfactory evidence directly on their behalf.<sup>1</sup> Proponents of this view contend that we reason by hypothesis when, on the basis of such assumption, we try to deduce consequences for which we should have or be able to find empirical evidence.<sup>2</sup> That we then seek

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<sup>1</sup> Plato is one such classical proponent of this view. In the *Phaedo* and the *Republic*, for example, he relies extensively upon hypothesis in developing the Theory of Forms.

<sup>2</sup> Plato writes in the *Phaedo* (101d):

If anyone should fasten upon the hypothesis itself, you would disregard him and refuse to answer until you could consider whether its consequences were mutually consistent or not. And when you had to substantiate the hypothesis itself, you would proceed in the same way, assuming whatever more ultimate hypothesis commended itself most to you, until you reached one which was satisfactory.

(Plato, *Phaedo*, trans. Hugh Tredennick, in *Plato: The Collected Dialogues*, ed. Edith Hamilton and Huntington Cairns (Princeton: Princeton University Press, 1961).)

support for the hypothesized items by further, optimally direct evidence is quite another task, and it is no small question as to when we have such support. But no matter the approach to this last issue we first need to decide what counts as initially admissible conjecture, under what circumstances we should have recourse to hypothetical reasoning, and when we have legitimate instances of the same—that is, when hypotheses advance scientific knowledge.

The roots of Gassendi's views on these issues lie in his suggestion that we reason about the world by generalizing on particular sensory experiences and inferring claims about non-apparent phenomena from claims about apparent phenomena. The ready analogue in the context of scientific inquiry is that, on the basis of what evidence we have, we form hypotheses about phenomena for which we have no direct empirical evidence. Although Gassendi embraces this analogue, he worries that pure conjecture provides poor foundations for science. Instead, he insists, any hypotheses we consider as starting points for reasoning about empirical matters must be based on reports of sensory data. Further, we should refrain from taking to be true those claims which we demonstrate on the basis of hypotheses, given that such starting points have not themselves been demonstrated to be true. He has qualms, as we have seen, about our ability to know *any* truths with certainty. Accordingly, he is not concerned with the actual truth of hypotheses so much as their resemblance to the truth, or verisimilitude, which he takes to be a function of their empirical adequacy—rather broadly construed. Just as we should initially consider only those hypotheses for which we have some minimum of empirical evidence, we should retain only those upheld by our best evidence, which he understands to include evidence from signs.

### 1. *Early Modern Method of Hypothesis*

To grasp the distinctive character of Gassendi's views on hypotheses it is helpful to recall the debate in his times over whether hypothetical reasoning has a place in science at all. As surprising as this might be in our own times, the received historiography provides an additional, curious complexity. The early modern debate is typically construed to have taken place between proponents of the use of hypotheses who maintained the possibility of *a priori* knowledge about

the natural world, and opponents of hypotheses who denied such a possibility.<sup>3</sup> According to this construal, the claim that there is no place in science for reasoning from hypotheses further suggests that we violate empiricist principles by relying on speculation or presupposition beyond our observation reports. This view has been standardly associated with Francis Bacon (less so in more recent scholarship), who was traditionally seen as holding that reliance on presupposition violates the principle that empirical inquiry consists in learning from observation reports alone. The underlying general principle is that all knowledge is from the senses. Hypotheses, accordingly, represent idle, groundless conjecture, unsuitable for the foundations of science.<sup>4</sup>

We might think it an improbable task to eliminate conjecture or presupposition from scientific reasoning—and we might also think it undesirable if it turns out that good science requires speculation

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<sup>3</sup> We can find this neat division in, for example, Ralph M. Blake, Curt J. Ducasse, and Edward H. Madden, *Theories of Scientific Method: the Renaissance through the Nineteenth Century* (Seattle: University of Washington Press, 1960), John Losee, *A Historical Introduction to the Philosophy of Science* (Oxford: Oxford University Press, 1972), and David Oldroyd, *The Arch of Knowledge* (New York: Methuen, 1986). Larry Laudan, for one, does not accept this division; q.v. his *The Idea of a Physical Theory from Galileo to Newton: Studies in Seventeenth-Century Methodology* (Ph.D. diss., Princeton University, 1966a), and *Science and Hypothesis* (Dordrecht: D. Reidel, 1981).

<sup>4</sup> In characterizing this standard view, Urbach (1987, 26) points to interpretations by Jevons, Cassirer, Cajori, and Popper that suggest that Baconian science precludes hypothesis, conjecture, or speculation. A recent alternative—current in commentary on Bacon—allows that, while Bacon rejects certain forms of hypothetical reasoning, he accepts hypotheses *per se*. In particular, we cannot have induction by ampliative inference unless we make such inferences from our data as are *a fortiori* merely hypothetical; q.v. Urbach (1987); Pérez-Ramos (1988); Gaukroger (2001); and Lisa Jardine, *Francis Bacon: Discovery and the Art of Discourse* (London; New York: Cambridge University Press, 1974). In Urbach's version of this picture, Baconian hypothetical reasoning consists in induction coupled with a proto-Popperian view that we test such hypotheses by observation reports—and if they fail, we change the hypothesis. This interpretation accommodates Urbach's view that Bacon only objects to hypotheses insofar as they have a 'dogmatic' character and serve as the basis of unwarranted speculation, where we take them to be 'certainly true and beyond revision' (1987, 36). Urbach further suggests that Bacon does not ban hypotheses because he recognizes our reliance on them for going beyond the immediate evidence and observational givens; this is a view that we will see is quite close to Gassendi's. One problem with this alternative line of interpretation is that Bacon does not spell out ways in which induction involves hypothetical reasoning. That is, he does not say how having a conjectural base may be reflected in the character of induction. Moreover, he truly is suspicious of conjecture—which he believes to pose the greatest difficulties in the premises, rather than the inferential structure, of scientific reasoning.

beyond what is empirically evident. This is the suggestion of those early modern critics of the strong empiricist view typically attributed to Bacon and his followers: we need to go beyond mere induction on observation reports, they claim, if we are to grasp underlying causes and unifying principles in science, for these are not subject to observation. The more common and perhaps natural variant of this suggestion, which we find in Kepler, Galileo, Descartes, and many others, is based on generally non-empiricist principles. Distinctly less common is the variant, which we find in Gassendi, based on empiricist principles.

For Kepler, Galileo, and other early modern astronomers, the main reason to accept that science has a warranted hypothetical component is simply that astronomy does not go far enough on the basis of observation alone. Kepler argues for his laws of planetary motion on the basis of their conformity, not merely with sightings, but with mathematically-derived conjecture about what he understands to be necessarily the structure of the solar system (as described, most notably, by his area law). Galileo, for his part, suggests science requires a conjectural element to provide imagined abstract approximations of physical and astronomical objects—such as spheres rolling on planes, bodies in free fall, or planets in orbit—which we need in order to spell out laws governing the behavior of such objects.<sup>5</sup> Such conjecture thereby helps us to overcome finite limits on our grasp of the possibly infinite range of physical phenomena.<sup>6</sup> For these writers the appeal of the hypothetical stems from their view that our best characterization of the world is imagined (and idealized, for Kepler) and that, unlike any picture we build upon fallible data concerning further phenomena, that characterization may be guaranteed as true by demonstrative proofs similar to and including those we summon in mathematics.

We find a different non-empiricist defense in Descartes, who employs hypothetical reasoning throughout his scientific writings. Like

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<sup>5</sup> Galileo is standardly viewed as taking such imagined abstract approximations of objects as idealizations (*ENI* 298–300). A problem with this view, Martin Tamny has suggested, is Galileo's insistence that astronomy and physics concern the real and not the ideal. The standard view might be fruitfully reformulated as the proposal that we best grasp Galilean science if *we* understand what he took to be imagined but possibly real objects—such as frictionless planes or perfect spheres—as ideal.

<sup>6</sup> Galileo was noncommittal, or perhaps simply undecided, about whether the universe is infinite.

Kepler and Galileo, he also wants a picture of the world that is certain and rests on secure demonstration. But the primary reason he thinks we need conjecture beyond experience in science is rather that his prescribed method of ‘analysis’, or reasoning from data to first principles, demands hypothetical reasoning. This is not quite so of ‘synthesis’—deduction of actual facts *from* first principles—which he supposes to be evident by the light of reason.<sup>7</sup> Even if Descartes were to count such principles as conjectural, he could not view them as *empirical* hypotheses;<sup>8</sup> but since they are founded on the bedrock of reason he does not think they are conjectural to begin with. By contrast, analysis is built on experience, and so the relevant methods are empirical ones—among which Descartes counts hypothetical reasoning in at least two respects. First, we use hypothetical models to show analogies between perceptually familiar and less familiar mechanisms, where the less familiar ones are usually perceived indirectly if at all. This is the strategy Descartes employs in appealing to his tennis-ball analogy to explain the mechanical behavior of light in *On Light* (the *Dioptrics*).<sup>9</sup> Second, we assume the existence

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<sup>7</sup> Q.v. chapter four.

<sup>8</sup> Even if they are neither based on, nor maintained on the strength of, experiential data, one might think we should count cartesian first principles as empirical hypotheses because of their clear empirical content—such as seen in his laws of nature, e.g. the second law, that all movement is of itself along straight lines (*PP* II §32; *AT* VIII A 58). But Descartes advertises even such straightforwardly physical principles as part and parcel of geometry or mathematics, and asserts that we need only principles belonging to those abstract studies in order to explain the range of physical phenomena (*PP* II §64; *AT* VIII A 78–79).

<sup>9</sup> Q.v. for example *AT* VI 90–92. This particular cartesian analogy is curious relative to Gassendi’s view of light: whereas both Descartes and Gassendi hold that light is refracted and reflected in a mechanical fashion, only Gassendi takes it to be literally the case that light is corpuscular. For Descartes the tennis-ball model may give a corpuscular picture of light suitable for explaining refraction and reflection, but we need a different picture to explain other elements of the mechanics of light (such as a model of light as rod-like to explain transmission). Buchdahl sees these varying models as (1) inconsistent and thus (2) evidence that Descartes did not take any of his hypothetical light models as the only one he thought to be correct; q.v. Gerd Buchdahl, “Descartes’ Anticipation of a ‘Logic of Discovery’”, in *Scientific Change*, ed. A.C. Crombie (London: Heinemann, 1962), 399–417. Of course, Descartes could not take them all to be true if they were inconsistent. However, it *is* possible he believed one hypothesis to be stronger or more likely than another. Further, it is not clear that drawing on such different models must yield an inconsistent view of the nature of light. For if Descartes uses each model simply to provide an analogue with which to *explain* a distinct set of light’s mechanical properties, then using the two models need not commit him to the ontology of either. Gassendi has less flexibility in this regard, having latched on to the corpuscularian model.

of hypothetical entities to fashion explanations that unify our observations. In the *Principles*, for example, Descartes proposes that we best explain the observed motions of the planets by assuming that matter in the heavens moves along vortices. But in either respect, the reason for introducing hypotheses is that we need to make *whatever* assumptions our demonstrations require, as long as we can show they are foundational or follow from foundational principles—and those assumptions are not to be had from experience. We draw upon conjecture, then, to help account for what experience cannot provide. The appeal of the hypothetical thus rests on methodological needs that we determine on the basis not of what we know, but what we do not know, from the senses.

One alternative to these opposing views—generally ignored in the historical review of this debate—offers *empiricist* grounds for admitting a hypothetical component to science.<sup>10</sup> This is Gassendi's approach.

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<sup>10</sup> As Sophie Roux relates in detail, among early modern thinkers the mechanical philosophers had a special interest in hypothetical reasoning; q.v. “Le Scepticisme et les Hypothèses de la Physique”, *Revue de Synthèse* (fourth series) 2–3 (1998), 211–255. She outlines some six defenses of recourse to hypothesis, only one of which—the appeal to microscopy—is of a straightforwardly empiricist character:

(1) Given the hints and distortions of sensory-based data, further sources and means of understanding are required to fully grasp the nature of bodies; q.v. Bernard Lamy, *Entretiens sur les sciences, dans lesquels, outre la méthode d'étudier, on apprend comme l'on se doit servir des sciences, pour se faire l'esprit juste et le coeur droit et pour se rendre utile à l'Église. On y donne des avis importants à ceux qui vivent dans des maisons ecclésiastiques* (Grenoble: A. Fremon, 1683); Pierre Clair and François Girbal (eds.), *Entretiens sur la Science*, Presses Universitaires de France, 1966; and Pierre-Sylvain Régis, “La Physique”, in *Système de philosophie concernant la logique, la physique, et la morale*, Three volumes (Paris: Denys Thierry; Lyon: Anisson, Posuel & Rigaud, 1690; Reprint edition, New York; London: Johnson Reprint Corporation, 1971).

Like Gassendi, Lamy points out limits on our epistemic access to hidden natural mechanisms, and proposes that we grasp those mechanisms only through conjecture and attempts to verify the same (further, the amplified perception provided by microscopes and telescopes can help in these efforts; q.v. (6) below). Régis distinguishes between observable elements of physical accounts (the perceivable effects of underlying phenomena) which allow for ‘practical’ mathematical description, and unobserved elements (the causes of such effects) which lend themselves not to demonstration but to ‘problematic’ consideration. Roux suggests what Régis intends here corresponds to the Epicurean notion of multiple possible explanations, echoed by Gassendi (*O I* 286b).

(2) Following Aristotle, we can satisfactorily explain phenomena beyond the senses if such explanations ‘save the phenomena’, accounting for all the relevant facts; q.v. *Meteorology I* 7 344a 5–7.

(3) Signs provide evidence of subperceivable phenomena; q.v. Gassendi, *O I* 81a; and Edmé Mariotte, *Essai de Logique* (Paris: E. Michallet, 1678); Reprint edition, Guy Picolet and Alan Gabbey, eds., (Paris: Fayard, 1992), I §44, 52.

He agrees with Bacon that to be able to consistently call an account 'empirical' it must accord largely with the data, but disagrees (with Bacon's view as traditionally construed) that this implies prohibitive strictures on either conjecture beyond observation reports or induction on the same. Indeed, as we have seen (chapter four), Gassendi anticipates Glanvill and Hume in observing that induction actually requires an ampliative hypothesis which might not be either found in or directly warranted by the available data. Bacon's acceptance

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- (4) Hypotheses in physical theory are an extension of the *regula falsi* of mathematics; q.v. Robert Boyle, *Experiments and considerations touching colours* (London: Henry Herringman, 1664; Reprint edition, New York: Johnson Reprint Corp, 1964); and Robert Hooke, "Of Comets and Gravity", in *The Posthumous Works of Robert Hooke, M.D., S.R.S., containing his Cutlerian lectures and other discourses, read at the meetings of the illustrious Royal Society*, ed. R. Waller (London: Smith and Walford [Printers to the Royal Society], 1705; Reprint edition, London: Frank Cass & Co., 1971).
- (5) Hypotheses in physical theory are an extension of the suppositions or conjectures of astronomers; q.v. Gassendi, *O IV (PGDA)* 635a; Beecman, *Journal* I 34; and Pascal, *OC* (29 Oct 1647 to Père Noël).

Proponents of this claim followed those sixteenth century astronomers who identified hypotheses as uncertain at root, either out of a basic epistemic probabilism or else because they echoed a Ptolemaic notion of fictive models; q.v. Jardine (1979, 146–153; 1984, 229–243); Roux (1998, 238–240). As we have seen, Descartes offers the alternative view that such false or uncertain suppositions, corresponding to observational data, yield 'true and assured' consequences (*AT VI (Dioptrics)* 83). I discuss relations among these views below.

- (6) Microscopes extend empirical understanding in the way that telescopes do; q.v. Bacon, *NO* II 39; Henry Power, *Experimental philosophy, in three books: containing new experiments microscopical, mercurial, magnetical. With some deductions, and probable hypotheses, raised from them, in avouchment and illustration of the now famous atomical hypothesis* (London: T. Roycroft, for John Martin, 1664); Robert Hooke, *Micrographia: or some physiological descriptions of minute bodies made by magnifying glasses. With observations and inquiries thereupon* (London: Jo. Martyn and Ja. Allestry, 1665), note 71; Joseph Glanvill, *Plus Ultra; or the Progress and Advancement of knowledge since the days of Aristotle. In an account of some . . . late improvements of practical, useful learning . . . Occasioned by a conference with one of the Notional way* (London: For James Collins, 1668) chapter VII; and Gassendi, *O I* 82a.

Early modern astronomers viewed the telescope as a means of revealing the hidden structures of the skies in virtue of moving beyond limits on the senses and so helping to choose among competing hypotheses. As Roux notes (1998, 240–241), the mechanical philosophers saw similar potential in the microscope for revealing ultimate structures of matter, also in virtue of lending evidence for one or another of competing hypotheses. I discuss the roles of enhanced vision below and in chapters twelve and fourteen.

Roux suggests (*Ibid.*, 241) that these various references by mechanical philosophers to hypotheses in astronomy were intended primarily as a rhetorical gesture in opposition to an Aristotelian science accompanied by certainty. In particular, they sought to promote a parallel with well-regarded practices of a scientific domain generally viewed as better established than matter theory.

of induction as a secure method of inference founded on our data alone is, at least in its traditional (simple) guise, something of an act of faith. By contrast, Gassendi holds that the strength of at least one class of inductive inferences and much other conjecture-based reasoning, relies upon a thesis for which he thinks we have good empirical evidence. This is the thesis that a physical continuity exists across perceivable and imperceivable domains, such that physical laws governing the behavior of bodies are invariant to their scale (and so their perceivability)—no matter their great variety in other dimensions. The empirical evidence for this proposed physical continuity (and the scalar invariance thesis it supports), in his view, can be found in predictions about the micro-sized world shown to be correct by advances in microscopy.<sup>11</sup> If such a physical continuity characterizes the spectrum of bodies, he suggests, then we have grounds for accepting ampliative inferences from claims about the perceived to claims about the unperceived.<sup>12</sup> Such inferences are perforce conjectural, but for Gassendi these are the kinds of conjectures or hypotheses which, if rooted in experience, we want to initially admit for consideration. What is exciting for him about these particular conjectures is that they carry over a robust picture of mechanical explanation, without changes, from visible to subvisible domains.<sup>13</sup>

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<sup>11</sup> *O* III (*DM*) 354b–355a; *AN* 220–221. As noted in chapter three, Gassendi is curiously unconcerned about the great amount of *disconfirming* evidence provided by microscopy in this regard.

<sup>12</sup> One potential problem here is demonstrating such a physical continuity, or the concomitant scalar invariance thesis, empirically or otherwise; q.v. chapter twelve. The scalar invariance thesis, by the way, is a subthesis of the grander ‘homogeneity’ thesis which Pyle (1995) sees at the heart of a mechanistic atomism from antiquity onwards. This latter thesis suggests bodies are sufficiently similar, regardless of size, shape, or other features still, that their behaviors all obey the same class of physical laws.

<sup>13</sup> There are similarities here with Descartes’s motivation for developing a method of hypothesis—but there is at least one difference. Descartes thinks we need hypothetical models like his tennis-ball model of light-corpuscle behavior because the senses cannot give us any information about light-corpuscles, so we need to invent a reasonable story to bridge this gap. Gassendi, on the other hand, thinks such models help explain what is perceivable: what we actually perceive, we take to be indicative of the unperceivable. In brief, we incorporate hypotheses into our scientific accounts just in case they are experientially based and so underwrite the role of the senses as a source of information, even about things we cannot directly sense.

Roux (1998), following Larry Laudan (“The Clock Metaphor and Probabilism: The Impact of Descartes on British Methodological Thought, 1650–65”, *Annals of Science* 22 (1966b), 73–104), offers a contrasting view, drawing on Descartes’s ‘clock metaphor’ wherein our inability to understand the inner workings of artificial mech-



## 2. *The Empirical Grounds Requirement, and Its Satisfaction*

We find one important clue to the kinds of hypothetical reasoning Gassendi endorses in his definition of ‘hypothesis’. According to one formula he offers, an hypothesis is “. . . an invention that is probable and adapted for calculations”.<sup>14</sup> Given Gassendi’s adherence to common early modern usage of ‘probable’, the term as it appears here means not so much ‘likely’ as ‘unproven yet plausible’—a notion which includes the idea of being ‘capable of being approved’. In the passage where this formula appears, he is weighing an abstract hypothesis of astronomy, namely, that the motion of starry bodies in ether causes the motion of the earth. Thus ‘calculations’ entails likely not computation in a purely mathematical sense (which would have no bearing on determining the physical nature of what moves the earth); rather, quantified accounts of the observed phenomena as projectible across time, and as taken to confirm or follow from a given model (or ‘hypothesis’). Looking beyond astronomy, this may be generalized as whatever practicable method we may use to determine the viability of a further claim. Whether or not he subscribes to this more general sense of ‘calculation’, Gassendi views at least this one sort of acceptable reasoning from hypotheses as consisting of drawing inferences from conjectures we think are not only plausible, and which we embrace in particular because we think they will facilitate such calculations or determinations.

By contrast, one point *not* made here is that hypotheses give us a certifiably true or precise account of the phenomena. Indeed, in the *Disquisitio* Gassendi says why we should not look for this quality, in a passage where he reminds Descartes of ancient Skeptical caution about the use of hypotheses in geometry and astronomy. The ancients, he writes,

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anisms—and by extension, natural mechanisms—is only as a contingent feature of our present depth of experience. This metaphor holds out the promise of eventually grasping the underlying mechanisms, whereas Gassendi is at times more pessimistic on this score, citing the limits of human understanding (234; q.v. *O* III (*Letter to Cherbury*) 413b; *O* III (*DM*) 312b, *R* 188; *O* I 125b–126b). Yet his pessimism in those sections is counterbalanced by an optimism relative to knowledge of the hidden, via the right sorts of inference—including appeals to signs. While he never proposes the certitude on offer from Descartes, that is not cause for despair in Gassendi’s view. Rather, this probabilism is a *modus vivendi* that enables some epistemic grasp of the hidden mechanism—namely, that to which the current state of our investigations entitle us.

<sup>14</sup> *O* I 630b.

... raised doubts concerning the method of proving by hypotheses, not insofar as they were conducive to stimulating the attention or revealing the solution being sought, but insofar as they were held to be so right and true to nature that actual things would be assumed to be exactly the way the hypothesis supposed they were...<sup>15</sup>

However plausible or likely our conjectures may seem, it is dangerous to take them to be true unquestioningly, because we may lack proof or even any supporting evidence on their behalf. Gassendi undercuts what he takes to be Descartes's argument for entertaining only those hypotheses we think are necessarily true, namely, that what is merely conjectural perforce cannot be indubitable. This approach echoes the view Gassendi attributes to the Skeptics, namely, that we may accept an instrumental role for hypothetical claims in demonstration, if we carefully check the accuracy of each claim:

... you would not see [the Skeptics] proposing doubts against demonstrations, or clear natural principles that are neither hypothetical nor suppositious [*supposititia*], but only against the very hypotheses [*ipsas hypotheses*] about which they would first ask 'if such a thing ought to be accepted by hypothesis'.<sup>16</sup>

It is one thing to question the place of hypotheses altogether, and quite another to question whether any particular claim is an acceptable hypothesis. The suggestion is that the Skeptics do not worry globally about the use of hypotheses to generate demonstrations and predictions. What concerns them is rather that we might prematurely impute truth or correctness to our conjectures (hence no hypothetical "clear natural principles") or that we might not closely examine whether a given claim "ought to be accepted by hypothesis."<sup>17</sup> Their 'dogmatist' opponents—including, prominently, the Stoics—suggest we are warranted in counting hypothesis-based claims as true

<sup>15</sup> *O* III (*DM*) 384a; *R* 510; *B* 265–266; q.v. also *O* I 84; *B* 340.

<sup>16</sup> *O* III (*DM*) 384a; *R* 510; *B* 265–266. Brush translates '*Sit-ne aliquid ex hypothesis accipiendum*' as 'if that ought to be accepted as a hypothesis', which makes Gassendi's Skeptic appear obtuse. Why, after all, would we *not* minimally accept a given hypothesis as a hypothesis? Gassendi is rather noting the Skeptical tendency to question whether a given claim could be attributed hypothetical status and 'accepted' accordingly.

<sup>17</sup> The Skeptics value such results anyway for their 'stimulating' or 'revelatory' properties—which they apparently feature even if false. Gassendi, as we see below, does not share quite this view because he thinks the same judgments we find stimulating or revelatory also approximate the truth in some fashion.

just in case we count our hypothetical assumptions as true. They propose that their method allows us to construct systems of beliefs without first (and terminally) worrying about their foundations. The Skeptical view, which Gassendi embraces here, suggests in response that if the truth of our initial assumptions has never been demonstrated then neither has the truth of any claims premised only on the same.<sup>18</sup> This much is an accurate recounting of the ancient debate, though it misses the point of the Stoic suggestion, that for the sake of constructing coherent belief systems we may accept proofs on the basis of otherwise unwarranted assumptions. That is ostensibly our principal motivation for adopting axiom-based systems.<sup>19</sup>

In just this vein Craig Brush (1972) suggests that Gassendi fails to understand the nature of axiom systems and so rejects axiom-based proof.<sup>20</sup> But nowhere in Gassendi's view do we find the suggestion that it is impossible to have proof in a system built on a fixed set of foundational claims or axioms for which there is no proof in the system. Rather, we find the simpler notion that no demonstrations which rely on unwarranted claims (empirically or otherwise) have a place in empirical inquiry (where, along Millian lines, he includes geometry). This reflects a fair bit of caution, he points out, for if we based demonstrations on claims about the world we thought were 'absolutely true' without experiential support, we would undermine the purpose of our demonstrations by failing to provide the requisite empirical warrant.<sup>21</sup> A significant difference looms between this methodological prescription and his actual physical theory, though. Whereas Gassendi wants a physics with a purely empirical basis, in

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<sup>18</sup> *O* III (*DM*) 384a; *R* 510; *B* 265.

<sup>19</sup> The Skeptics, by contrast, do not even want a mathematics or geometry based on axioms, on the grounds that such axioms would bear no real-world referents and therefore refer to no particular thing that can be known. But Gassendi parts company with the Skeptics here and recalls Aristotle's suggestion that we can posit, for example, that line is length without width just in case we are interested in the properties of length, and not width or anything else (*O* I 84; *B* 340). Broadly, there might be formal or conceptual reasons for stipulating postulates without real-world referents; for example, that such postulates should be acceptable as long as they are clearly defined and we deem them significant for the theory. While such reasoning is a plausible construal of Gassendi's intuitions here, it is also important to recall that he has an extremely catholic notion of the sorts of mathematical and geometric properties that have real-world referents.

<sup>20</sup> *B* 266n.

<sup>21</sup> *O* III (*DM*) 384a; *R* 510; *B* 265.

the end he relies strongly on foundational physical or metaphysical principles and on claims based on historical authority for which he fails to provide empirical demonstration; I discuss this further in Part III. However, this is not the problem Brush suggests, that Gassendi cannot have a coherent notion of proof from axiom-like assumptions.

Gassendi's view is not without flaws, yet it is novel in the context of his times, and clearly not identical to that of the Skeptics. For while he does not think we should reason from hypotheses lacking empirical support, he sanctions the use of unproven hypotheses in empirical demonstrations provided that (1) there is *some* evidence by which they might be justified, (2) our considered judgment of them is withheld, pending such evidence, and (3) we recognize, accordingly, our inability to know as true claims demonstrated in this way. By insisting that (1) can be satisfied, Gassendi parts ways with the Skeptics. The latter two conditions standing alone resemble Skepticist positions, though not as conditions the satisfaction of which might sanction the use of unproven hypotheses.

This view also contrasts with the account in the *Discourse*, where Descartes suggests that our warranted claims follow in part from axioms, first principles, or other such foundational beliefs for which, though we may lack empirical proof, are evident by the light of reason—and so definitive, not provisional.<sup>22</sup> There is a faint echo of this cartesian view in Gassendi's *Institutio* method, when he insists that discoveries in science progress by demonstrative proof. Yet even

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<sup>22</sup> It is crucial to distinguish between Descartes's earlier and later methodological views, as developed in the *Discourse* and *Principles* (as well as the *Essais* and *Le Monde*), respectively. In the *Principles*, Descartes suggests that hypotheses without a foundational basis may indeed contribute to the analytic (empirical) phase of a scientific inquiry. Indeed, Roux (1998, 220) suggests, the later cartesian method does not even demand certitude regarding claims drawn from metaphysical certainties, given that various such claims may be so deduced; q.v. *PP* III §4, *AT* IX-2 105, VIII-1 81.

Yet Descartes shows a clear preference for certainty, all things considered: such hypotheses as lack a basis in foundational truths are only worth maintaining, he holds, if they fit into the deductive framework of the synthetic phase. The tennis-ball model and vortices, for example, are suitable to the *Principles* framework because they are no longer (individually and literally) hypothetical but drawn deductively from higher-order principles. And where metaphysical certainties yield various possible consequences, we should turn first to general principles to help us pick out the sole viable explanations. Only after exhausting such possibilities may we turn to evidence from the senses, and as a final resort we may accept multiple possible accounts; q.v. *PP* III §132, *AT* IX-2 185, VIII-1 185.

there it is conceded that a great many such proofs yield claims that are far from certain because the premises on which they rest are uncertain, too. Moreover, Gassendi distinguishes his view by suggesting that, though we must mount additional evidence to eventually confer approval upon such hypotheses, no amount of evidence will ever lead us to characterize them as definitively true. Whereas Descartes claims that the foundations of scientific reasoning are secure only if they are indubitable, Gassendi proposes that any starting point for scientific reasoning is secure just in case it is based on the best available experimental and observational evidence. This point is clearest in his insistence that we seek an evidentiary basis for the hypothetical element of science in experiential data.

In this vein, Gassendi praises Tycho Brahe as an exemplary astronomer, for basing inventive hypotheses on keen observation and careful charting of the motion of heavenly bodies:

[Tycho's] hand was completely stretched out to submitting observations to calculation . . . in order to obtain the multiple locations of each planet, and to explore with coherence relative to these imagined hypotheses and to correct them, unless the noted observations perhaps did not tally with even better ones; and this because tables of that sort could finally be founded, by which derived movements would be in perfect agreement with the sky; that was his first and supreme wish.<sup>23</sup>

By contrast, he decries the astronomy of Jean-Baptiste Morin as occult because it is based on hypotheses and charts of the skies which Morin formulates without bothering to first make observations. In his polemic against Morin, Gassendi writes:

. . . you . . . gave hypotheses and drew up tables, about which there is nothing there to be said? . . . You have never made observations; You have never worked on making hypotheses on any observations, neither of your own, nor of others? You have never composed tables on any hypotheses. What could [one] think of you, if it is not this: PARTURIENT MONTES?<sup>24</sup> When [someone] opens your book, and sees there only some small fragments, fifteen days each, and all made in an office without seeing the sky: is knowing your argument concerning

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<sup>23</sup> *O V (Vita Tychonis Brahei)* 460a; *VT* 158. Indeed, Gassendi concludes from his own astronomical observations that, although Tycho's observations were partly discredited by Kepler, his charts were in the main highly accurate.

<sup>24</sup> *Parturiant montes, nascetur ridiculus mus* (Horace, *Ars Poetica*, 139): To those who desire to bring forth mountains, a ridiculous mouse will be born.

longitudes, with the treatise of the equation of time, [also to know] parallaxes, and refractions? Will he have occasion to believe that this is the whole of astronomy reestablished in its entirety?<sup>25</sup>

Gassendi takes Morin to task for not even bothering to draw on someone else's observations as a foundation for his hypotheses, and for not forming celestial tables on the basis of well-formed hypotheses. Even if Morin and other armchair astronomers do not first peer at the sky, their hypotheses should be formulated on the basis of borrowed data—those who watch the sky—and their charts designed accordingly.

While Gassendi insists we have no warrant for conjecture without some basis in experiential data, he himself adduces much non-empirical (theological, historical, and philosophical) evidence for his own physical picture, and in particular for his atomism. Yet he also holds great hopes for empirically supporting his atomist picture; I explore that picture in depth in Part III. The broader context, however, is his general suggestion that we have experientially-based grounds for hypothesizing about things (such as atoms) which *ex hypothesi* have no corresponding appearances. We need such hypotheses, Gassendi proposes, to understand the underlying structure of the world despite

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<sup>25</sup> *RL* 134–135.

In a collection published fifteen years earlier, Morin includes a letter from Gassendi in an effort to lend credence, or at least prominence, to Morin's proposed solution to the problem of longitudes; q.v. *Lettres écrites au Sr Morin par les plus célèbres astronomes de France, approuvant son invention des longitudes, contre la dernière sentence rendue sur ce sujet par les sieurs Pascal, Mydorge, Beaugrand, Boulenger et Hérigone, commissaires députés pour en juger, avec la réponse dudit sieur Morin au sieur Hérigone, touchant la nouvelle méthode proposée par iceluy Hérigone . . .* (Paris: Chez ledit Sieur Morin, 1635) and Monette Martinet, "Gassendi, J.-B. Morin et le Secret des Longitudes", in *Société Scientifique* (1995) volume II, 397–410. That letter was not intended by Gassendi for publication, however, and so began a long and acrimonious dispute between the two philosophers. Gassendi's letter in the *Recueil* marks his definitive dismissal of Morin's judiciary astrology and—as is evident in the passage cited here—the justification of his longitudes account. In his Inaugural Address to the Collège Royale, however, Gassendi offers more conciliatory words.

Morin's steadfast commitments—to astrology, Aristotelian matter theory, and geocentrism—motivated further criticisms of Gassendi. In his *Alae Telluris Fractae* (1643), he takes on Gassendi's *De Motu* (and the third letter of *De Motu*, published long after the first two, is Gassendi's response), and in his *Defensio suae dissertationis de atomis & vacuo aduersus Petri Gassendi philosophiam Epicuream* (Paris, 1651), he challenges atomism. So great was Morin's animosity that he was said to have called upon the stars to forecast Gassendi's death in 1650; q.v. Jacques Halbronn, "Pierre Gassendi et l'Astrologie Judicatoire. Approche Bibliographique," in *Société Scientifique* (1995), volume II, 255–270, esp. 260–261.

our limited perceptual access to it. Given those limits, then, what could those grounds be? Following the theory of signs, we arrive at such hypotheses by inferring claims about that nonevident part of the world's structure on the basis of claims about the evident part, either because of a regularity of correspondence between occurrences of the two (viz. inferences by commemorative signs) or else because we cannot conceive of the second existing without the first existing (viz. inferences by indicative signs).

Throughout the *Physica* and *Disquisitio*, Gassendi tries to justify such inferences by suggesting that we have good physical and historical reasons to believe the correspondences we postulate may be regular and productive. Under the regime of his global empiricism, these correspondences—which are, after all, further hypotheses—must be defended by appeal to experience. To this end, he extols the merits of the optical picture underlying microscopic and telescopic extensions of our visual perception, and the history of our successful experiences with the same. In this vein, Gassendi strives to demonstrate that microscopy and telescopic cannot fail to preserve information through the changing of light's path, even if that preservation relies on standard rules for interpreting our raw visual data. Such preservation is requisite for those correspondences to be reliable and accurate, given his view of visual data as information transmitted by the material medium of light corpuscles.

In short, his empirical defense of the correspondence between the evident and nonevident consists in the claim that whatever images we attain through the naked eye we should be able to magnify so as to provide finer details of the image. Such images should feature no other significant optical changes, except those distortions for which we can make accommodation through regular manipulation of the data.<sup>26</sup> Such a guarantee allows us to have as viable ideas of the contingently subvisible or supravisible as we do of the visible.

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<sup>26</sup> One well-known example of such regular manipulations consists in accounting for parallax in observations of the skies. Gassendi celebrates Tycho's advances in this sphere; q.v. *O V (Vita Tychois Brahei)* 474b–475a; *VT* 184–185. Gassendi also details another, much-discussed instance of optical transformation in his account of the apparent variation in the magnitude of the sun at different times of the day, *De Apparente Magnitudine*. He attributes each of these changes, however, to general environmental conditions rather than to the use of magnifying lenses *per se*. Bloch (1971, 17–18) notes that, for Gassendi, such problems are rampant in astronomical observation.

In Section Three of the *Physics*, he draws on his analysis of convex and concave lenses<sup>27</sup> to offer at least one element of such a guarantee:

This, then, can make us understand the [underlying] reasoning of telescopes. Since the ordinary telescope is made of two lenses, one convex and one concave, the rays are reunited by the convex lens in such a way that, before the reunion of cones similar to those that we have said are formed by the eyeball and to be transmitted to the retina, we place the concave which, dilating as little as those cones, pushes their points farther and at the same time makes them more distinct, so that having been received in the eyeball a little after crossing, they reunite a second time in the retina, and represent the thing as greater in proportion to the convexity. One proof that the thing is seen after the rays cross is that, as the rays are received on paper [after being focused through a convex lens] the thing is painted as inverted, and that nevertheless as seen by the eye through the telescope [*tubum*] it is seen right-side-up.<sup>28</sup>

The rays carrying parts of an image converge as they pass through a convex lens (which also inverts the image), and are refracted when they pass through a concave lens placed before the point of convergence. Hence, taking the former lens as an objective and the latter as an eyepiece, we get a magnified, focused, and non-inverted presentation of the image through such a telescope.<sup>29</sup> This much fails to guarantee that images are wholly preserved through the changing of light's path. Yet it does suggest images we receive through this kind of telescope are not any more distorted relative to focus than our unmagnified images of mid-sized objects, and not at all distorted relative to position. Of course, Gassendi could not rule out much other distortion, particularly given the immature state of magnifying technology.

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<sup>27</sup> Gassendi's understanding of convex and concave lenses is partly based on his familiarity—through Peiresc's work—with the behavior of microscopes, and—through his own astronomical observations—of telescopes. Other influences on his understanding include Galileo, Kepler, and other members of the Mersenne circle; q.v. Hatch (1995), 365–385.

<sup>28</sup> *O* II 384a.

<sup>29</sup> The telescope Gassendi received from Galileo was built in this way; q.v. Pierre Humbert, *L'Œuvre Astronomique de Gassendi* (Paris: Hermann, 1936), Albert van Helden, "Gassendi and the Telescope: Towards a Research Community," in *Société Scientifique* (1995), volume II, 329–339. In his *Dioptrics* of 1611, Kepler first suggests that such a combination of lenses would right the image and bring it into greater focus if the concave lens is placed before the point of convergence.



More crucially, though, to hold that such magnification yields evidence for hypotheses about otherwise nonvisible things requires not only that the lenses's distortion is at a minimum, but also an account as to why the mere act of enlargement itself does not yield gross distortion. As Gassendi puts it, "How do you say . . . when a face seen with a concave mirror becomes so large, that this greatness is true; when viewed with a telescope, a microscope, and generally with a convex lens, that things become so large; and when a finger appears large like a leg, a flea like a snail, a mite like a pea, that this greatness is true?" His answer draws on an analogy between two kinds of enlargement, through magnification and through physically coming closer:

I respond that it seems so, insofar as nothing—that is, no part or particle—that one sees becoming larger appears in one thing which is not truly there, or in another manner, could be supposed or assumed as from one place, and be said spuriously to be from somewhere else. Indeed, nothing else happens here than what happens when an object, seen from afar as small, comes closer and appears larger. So that in this way a thing now appears larger because more of its parts which formerly were divergent [directed towards another place] are now directed towards the eye and [because], being interposed between those things which were seen before magnifies the number of the thing's [visible] parts, increased to such an extent that it appears larger. Just as it happens in this way, so it does in other ways . . . (*ita modis illis contingit*).<sup>30</sup>

What ties the two kinds of enlargement together, and so warrants our taking magnification to enhance visual perception without a loss of perceptual information, is that in either case there is an increase in the number of an image's parts (in his atomist terms: an increase in elements of the corresponding configuration of light-corpuscles) which reach the eye. If a thing seems larger than before when we approach it, this is because we have increased the amount of information we have about it. Accordingly, we have a generally more accurate assessment of its character (though not necessarily its size). There is, Gassendi notes, a limit on this kind of increase before our assessment of size diminishes in accuracy, as when we are too close to an object to reasonably judge how big it is. Yet our overall characterization of small objects can only become more accurate by

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<sup>30</sup> O II 388a.

coming closer to them, since this enhances our perception of both their previously and newly visible parts. Moreover, in virtue of such enhancement, magnification through telescoping or microscopy also heightens the accuracy of our accounts of the heretofore nonvisible.<sup>31</sup>

Following these aspects of Gassendi's optical theory, we should not reject conjectures inferred from claims about the nonevident on the grounds that they are founded on distortions of perceptual data. To the contrary, the optical theory suggests, we base those inferences on techniques for enhancing perception that tend to preserve the character of such data. In addition, Gassendi offers a *positive* reason for licensing such conjectures, namely, that our experiences with those techniques have been greatly successful. Thus, in a passage of the *Disquisitio* where he proposes, against Descartes, that we may naturally and without the intervention of God enhance our initial ideas of things (and of God in particular), he recommends that interposing lenses between our eyes and those objects we do not directly observe allows us to make new perceptually-based claims about those objects:

... you consider the mite [*acari*] in effect as indivisible, as the mite is relative to our view. . . . In effect whereas the image or idea of a mite, whether traced in your eye, brain, or understanding (. . .) twenty-five years ago represented only a little whitish point without any distinct parts, today by contrast (since the invention of the microscope [*engyscopium*] and after its use) it represents to you an animal of small but appreciable size endowed with a head, tail, limbs, back, and other parts. . . . Say . . . in what way the particular ideas of the limbs of a mite, discovered by microscope, should be contained in the idea that we had of it before the microscope. I think [you can] not, because

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<sup>31</sup> Roux (1998, 241), following Meyerson, suggests this disanalogy: Telescoping (and the astronomical hypotheses it supports) relies on our explanation of like properties by like properties—there is no qualitative difference or difference in kind between the motion of terrestrial and celestial bodies. The main differences are in size and distance from the objects observed. On the other hand, microscopy (and the mechanical hypotheses it supports) relies on our explanations of properties A by reference to B, where A, B may be different kinds; q.v. Emile Meyerson, *Identité et Réalité* (Paris: Vrin, 1951), 334 ff. As we will see in chapters nine, ten, and eleven, it is not obvious that Gassendi has a viable notion of how to proceed in causal or explanatory terms from one set of properties to the next. In this he is no worse off than most other mechanical philosophers—though it may also be the case that many astronomers of his time are not much better off, for accepting in principle the notion of differences in kind between terrestrial and celestial motion (Gassendi himself being one obvious exception).

you know the lens's property of convexity too well to doubt that it augments the mite's visible appearance, thanks to the deviation and displacement of the smallest rays coming from the mite's different parts, which [without the microscope] due to the insufficiency of [the mite's] too-little surface, are found elsewhere—and do not produce on the eye particular images separated from others at [distinguishable] intervals. . . . If, nevertheless, you are not disposed to agree to the comparison with the mite, make the same comparison with the Moon or the Sun (or whatever object you would), before and after the invention of the telescope: the same thing will result.<sup>32</sup>

Gassendi may be faulted for premature optimism regarding the microscopy programme<sup>33</sup> but in this passage he identifies one case where magnification undeniably adds to our viable conjectures about the natural world. What allows us to say we have warrant for richly detailed hypotheses about mites, for example, is that we base inferences to those hypotheses on reports of seeing through a microscope parts not visible to the naked eye. Hence, Gassendi proposes, there should be perceptually-based evidence for empirical hypotheses if we are to call them plausible, even if the hypothesis in question is supposed to tell us about objects we cannot perceive without magnification. Such a standard, he proposes, reflects our good reasons—minimal distortion and success at discovery—for believing that enhancing perception through magnification preserves the nature of images (or, perhaps, other data) we magnify and subsequently consider as suggestive or supporting evidence.<sup>34</sup> If, on the other hand, we could not come up with any such perceptually-based evidence in advance, then there would be no reason to even consider hypotheses regarding the nonvisible as bases for 'calculating' or determining the viability of further claims. But here Gassendi's empiricist caution enters the

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<sup>32</sup> *O* III (*DM*) 355a; *R* 378–380. Christoph Lüthy notes that *acari* may refer to any number of small insects, and that discussion of the *acari* as having parts unseen by the naked eye is found in Lucretius (*RN* IV 111–122) and throughout early modern microscopy writings; q.v. Lüthy, "Matter and Microscopes in the Seventeenth Century", (Ph.D. Diss., Harvard University, 1995), 276–281.

<sup>33</sup> Curiously, his optimism regarding the telescoping programme was better warranted, again by reference to past success, and not to his views on optical distortion and correction.

<sup>34</sup> Here, too, Gassendi finds these reasons compelling because they are evidence of the regularity of, and productivity in, asserting correspondences between occurrences of evident and non-evident phenomena. Per his theory of signs, such correspondences allow us to infer claims about the latter from those about the former—in this case, for instance, reports of microscopic or telescopic images.

picture: even if such evidence can be produced, we are perforce not entitled to consider the claims based on hypotheses as true since they are based on conjecture, not truths. Further, we shall see, this reserve carries over to Gassendi's criteria for judging an hypothesis as a properly accepted view (that is, among our core scientific beliefs), by which standard no evidence ever suffices to consider an hypothesis as true.

### 3. *Mere Empirical Adequacy or Truth? Gassendi's via media*

This suggestion—that hypotheses we retain after empirical test nevertheless lack sufficient evidence to be regarded as true—resembles a traditional perspective which says that hypotheses, *qua* propositions, are not the kinds of things to which we attach definitive truth values. This perspective, and the converse position that hypotheses (again, *qua* propositions) may be straightforwardly true or false, are the respective bases of the primary competing views—throughout the history of methodological thought—about what it means to endorse hypotheses. The first view, which promotes a sort of 'mere empirical adequacy', says

(MEA) hypotheses are acceptable if they allow us to understand our empirical data ('save the phenomena' that appears to us), yet they cannot actually be true (or false).

This view ranges over propositions, not theories *per se*, yet it is clearly akin to the classical instrumentalism notably expressed in ancient and early modern contexts relative to Ptolemaic theories in astronomy. The second view insists that truth *per se* plays a crucial role in our warranted claims about the world, suggesting that

(T) hypotheses are accept if we know them to be true, and we know that they are true because we accept them on the basis of some indubitable evidence.

This view—again, concerning propositions, not theories—is close to the classical realism opposed to instrumentalism.<sup>35</sup> Gassendi's per-

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<sup>35</sup> The difference between MEA and T on one hand, and instrumentalism and realism on the other, consists foremost in the first representing an epistemic distinction, the second representing a metaphysical distinction. Insofar as we might

spective, though it resembles a traditional MEA perspective, actually represents a distinct, third contender. He suggests that—relative to its accuracy or verity—we accept a given hypothesis because (*qua* propositions) it comes closer to the truth, or is more *verisimilitudinous*, than any of its competitors. The basis for this recognition is neither indubitable nor merely a matter of agreement with the raw empirical data, that is, data about what is present to the senses. Instead, the basis for hypothesis acceptance is the relative strength of the total evidence in its favor.<sup>36</sup>

Let us place this view in historical context. We find T expressed by, among others, Copernicus and Galileo. Copernicus claims we know hypotheses are true just in case we have indubitable evidence for them, which he thinks we may find in their apparent consequences: “For if the hypotheses assumed by them [earlier astronomers] were not false, everything which follows from their hypotheses would be verified beyond any doubt”.<sup>37</sup> In his musings on *regressus* method, Galileo agrees that we may know some hypotheses to be true but suggests a different criterion: that we come to them by intuitions that *a priori* we cannot doubt. How are such claims *conjectural* if they are supposed to be based on intuitions we take to report *a priori* truths? His suggestion is that we accept those hypotheses to begin with, not because they are empirically adequate, but because they are obvious or intuitive—which follows from their being founded on further, indubitable truths.<sup>38</sup> Such claims are conjectural because they

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talk about theories as ‘true’—and the early moderns do so frequently—we are typically talking about the truth value of their constituent propositions.

While the epistemic and metaphysical issues are quite apparently related, they do not cover identical ground. Thus, it is perplexing to say ‘It may be true but I do not believe it’; it is far less so to say ‘It may be real but I do not believe it’.

In any case, while it is undoubtedly helpful to recall the affinities between the epistemic (MEA and T) and metaphysical (‘instrumentalism’ and ‘realism’), there is some debate as to whether all those we typically think of as instrumentalists or realists in the early modern era genuinely argued for such views as construed in the modern, Duhemian fashion; q.v. Robert S. Westman (ed.), *The Copernican Achievement* (Berkeley: University of California Press, 1975).

<sup>36</sup> Gassendi thinks the relative strength of hypotheses should be judged upon other elements, too, and that all these elements contribute to what counts as the best among available alternatives. I discuss this broader strategy—a brand of ‘inference to the best explanation’—in chapter thirteen.

<sup>37</sup> Nicolaus Copernicus, *Commentariolus*, in *Three Copernican Treatises*, trans. E. Rosen (New York: Columbia University Press, 1939), 28.

<sup>38</sup> *EN* II 159 and VI 67; q.v. Ernan McMullin, “The Conception of Science in Galileo’s Work”, in *New Perspectives on Galileo*, ed. Robert E. Butts and Joseph C. Pitt (Dordrecht: Kluwer; Boston: D. Reidel, 1978), 209–257, esp. 219–223.

also require empirical demonstration—in the *Discorsi* Galileo has his interlocutor accept by hypothesis a claim the ‘absolute truth’ of which is to be demonstrated later on, when it is shown to “correspond with and exactly conform to experience”.<sup>39</sup> One outcome of this view is that the bar is raised on what counts as acceptable conjecture: hypothetical claims meeting only the test of empirical adequacy will not pass (though had they been initially acceptable, then they would be demonstrable in virtue of conforming to experience).<sup>40</sup> It may be reasonable to claim that the viability of hypotheses should not be judged, at least insofar as they remain conjectural, by the test of experience. Yet the Copernican and Galilean alternative criterion of indubitable evidence itself provides dubious foundations for judging the acceptability of an hypothesis. For one, we could think ourselves unable to doubt something but just be incompetent to judge. A larger question—later posed by Gassendi against Descartes in a very different context—is why indubitability is supposed in the first place to be an indicator of truth.

Such questions cannot arise regarding MEA, though, given its suggestion that truth cannot be a criterion of the acceptability of hypotheses because they cannot be true or false. They simply fit, better or worse, to the data from observation and experiment. This picture of hypothesis acceptance enjoyed great popularity from medieval through early modern times, generally on theological grounds—chief among which is epistemic humility. We cannot really know what the true picture of the universe looks like, such humility suggests, because that would entail that we had God’s picture, and we do not want to pretend such omniscience.<sup>41</sup> According to this line of reasoning, it follows that no evidence counts as sufficient for endorsing any one view as true and calling all competitors false.<sup>42</sup>

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<sup>39</sup> *EN* VIII 208.

<sup>40</sup> By this standard, the Copernican picture is preferable over the Ptolemaic picture. While they both cohere with the available data, only the first picture can be a true hypothesis given the ‘intuitive’ principles Galileo propounds in the *Diologo*.

<sup>41</sup> One likely doctrinal motivation for this humility is the Church’s condemnations (of 1270 and 1277) of a number of Aristotelian theses on the grounds that they constrict our view of God’s omnipotence—God could create any worlds he wants to, with whatever physics he wants, and so forth. Edward Grant suggests that as a result of these condemnations, many scientists and philosophers sought plausible accounts of the way the world could be, but steered away from suggesting that the world actually was this or that way; q.v. Grant, “Hypotheses in Late Medieval and Early Modern Science”, *Daedalus* 91 (1962), 599–616.

<sup>42</sup> For example, among late medieval and renaissance astronomers, Jean Buridan

In the early seventeenth century MEA continued to hold sway for at least partly theological reasons. Arguing against Galileo, Cardinal Bellarmine proposes that the heliocentrist hypothesis is no more acceptable on scientific grounds than the geocentrist one since each saves the apparent phenomena, such that the choice among them should be made by the distinguishing criterion furnished by the Church. Descartes, for his part, proposes a version of MEA on the grounds that the world could have been fashioned any way the Creator wants. Hypotheses of cartesian science must cohere with first principles of metaphysics and with experience so that we may “deduce true results” from them (our guarantee against empirically false or physically impossible consequences).<sup>43</sup> Yet there may be multiple plausible accounts of the imperceptible workings of the universe. Thus, while his corpuscularian account is empirically adequate if it generates accurate results, it is not necessarily *true* since the micro-composition of matter could have been (indeed, may be) otherwise. In the *Principles* Descartes makes this point in the framework of his famous clock metaphor:

For just as the same artisan can make two clocks indicate the hours equally well and are exactly similar externally, but are internally composed of an entirely similar combination of small wheels; so there is no doubt that the greatest Artificer of things could have made all those things which we see in many diverse ways.<sup>44</sup>

The MEA criterion provides no guide by which to gauge that our accepted hypotheses are true, from which we might conclude that Descartes should worry that his method cannot yield scientific knowledge that consists of certain truths. Perhaps he takes solace from his earlier *Regulae*, where he points out that “. . . nothing that we

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and Nicholas of Oresme suggest one merit of the geostatic hypothesis is that it saves the astronomically apparent phenomena, and if there is any *other* reason to embrace this hypothesis, it does not include any astronomical evidence. Thus Buridan cites the ancient worry that projectiles should fall ‘out of place’ on a moving planet—which may entail observable events but, in his times, counts as non-astronomical evidence. And Nicholas suggests the relative character of our observations while in motion obviates *any* empirical criterion for choosing between competitor hypotheses, so that we must choose the geostatic view on theological grounds. Their views each suggest that, at least in astronomy, we accept hypotheses not because we find compelling empirical evidence of their truth but because they account for the apparent data and meet our pre-set conceptual constraints—whether philosophical or theological; q.v. Grant (1962, 606–608).

<sup>43</sup> *AT* II 142.

<sup>44</sup> *PP* IV §204; *AT* VIII A 327.

construct [by way of conjecture] really deceives us, if we judge it to be probable and never affirm it to be true. . . .”<sup>45</sup> That is, we do not set ourselves up for a fall if we do not expect to know, with certainty, our hypotheses to be true. At some points in his correspondence, Descartes throws such caution to the wind and proposes that we may judge an hypothesis to be true if it implies a particular result and we have good independent evidence for the result.<sup>46</sup> But this is not his considered view, as represented in the *Principles*. There he argues that we accept hypotheses if they meet particular formal and empirical criteria, rather than the epistemic criterion that we judge ourselves certain that they are true—for we cannot be certain in this regard.

One advance beyond the standard MEA and T claims is Kepler’s view that there are physical criteria, apart from what is observed, that may be brought to bear in choosing among competing hypotheses (‘physical’ here may mean such substantive claims of metaphysics, dynamics, or theology—all of which Kepler distinguishes from geometry as employed in predictive models, and from the observational evidence of telescopic data).<sup>47</sup> Kepler is somewhat agnostic in judging hypotheses we accept as true or, as Jardine puts it, merely “confirmed in all respects”.<sup>48</sup> It is not feasible, then, to locate his views firmly in opposition to T—indeed, Jardine sees Kepler’s views as a form of realism.<sup>49</sup> As Jardine notes, Kepler fails to satisfy the skeptic—who looks for a criterion by which to judge a hypothesis ‘true’—because he fails to specify substantive non-observational criteria, or what about them might yield the truth. If Kepler held some,

<sup>45</sup> *AT* X 424 (*Regulae ad directionem ingenii*, Rule 12).

<sup>46</sup> Q.v. for example the letter to Vatier of February 22, 1638 (*AT* I 563–564). Larry Laudan (1966a) notes that this view anticipates Peircean abductive inference, and as we will see here and in chapter thirteen, there are affinities to Gassendi’s view as well. One common difficulty of such views (which Descartes later recognizes) is that conflicting hypotheses might imply the same result, yet we would not want to say they are all true.

<sup>47</sup> Kepler, *Apologia Tychonis contra Ursam*, in *Joannis Kepleri astronomi opera omnia*, Ch. Frisch (ed.), Frankfurt am Main and Erlanger, Heyder & Zimmer, 1858, I: 240; cf. Nicholas Jardine, *The Birth of History and Philosophy of Science: Kepler’s A Defence of Tycho against Ursus, with Essays on its Provenance and Significance* (Cambridge: Cambridge University Press, 1984), and Rhonda Martens *Kepler’s Philosophy and the New Astronomy* (Princeton: Princeton University Press, 2000), esp. 59–62.

<sup>48</sup> Nicholas Jardine, “The Forging of Modern Realism: Clavius and Kepler Against the Sceptics”, in *Studies in the History and Philosophy of Science* 10 (1979) 2, 168.

<sup>49</sup> Jardine (1979), 141–173.



attenuated form of T, he was party to a strong tradition of appealing to the ineffable for a truth criterion.

Gassendi builds on Kepler's view and further proposes an alternative to MEA and T. An hypothesis is acceptable on the basis of all available evidence, and not just data reporting the apparent, as the MEA theorists propose. Further, such evidence indicates the hypothesis is *possibly* true, and not that it *must* be true, as the T theorists propose.<sup>50</sup> To begin with, Gassendi takes it as neither false nor a consolation that we cannot be certain that our hypotheses are true, and instead take them to be probable; it is rather a simple fact about the limits on our epistemic access to what is contingently non-perceived or imperceptible in principle. If we base conjectures on information about which we are less than certain, it cannot make sense to insist that the criterion for accepting an hypothesis is that we are certain it is true. Indeed, his view is that the ultimate structure of the world is sufficiently hidden to us that we can accept an hypothesis given its utility in scientific reasoning, and without ever needing to say it is true *per se*. To accept an hypothesis we only need to see that it *resembles* the truth, where such resemblance or verisimilitude is measured by the total empirical evidence *for* it, which for Gassendi comprises claims inferred from signs, as well as lack of evidence *against* it. In this way the criterion for judging hypotheses—their broadly construed basis in experience—mirrors the criterion for entertaining them in the first place, as suppositions of empirical reasoning. And so, when Descartes claims his suppositions in the *Meditations* are analogous to an astronomer's hypotheses, Gassendi protests that we cannot judge his claims as resembling the truth (let alone as certain truths) since they lack such a basis:

. . . the difference is great between your supposition and an astronomical hypothesis, for example. That is because the astronomers take something certain, namely, the observed position of the planets. Thus, to explain the cause of it they imagine circles that they do not conceive as fictive, but which they consider, if not real, at least as existing in a way that resembles the truth [*verisimile*], since it may come about that the planets follow them in their path. And the proof of this is that, if they thought that there exist other, more probable hypotheses, they would not fail to adopt them. But as for you, there is nothing

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<sup>50</sup> Another alternative, which Jardine (1979) identifies as Kepler's foil, is the skeptical view that there are *no* viable criteria for choosing among candidate hypotheses.

you kept as certain in order to adjust your prior suppositions, and as material of your hypotheses, you have nothing real nor resembling the truth, but a wholly pure supposition. And do not say that from this hypothetical falsity you extricate something of truth, as is this famous saying: *ego cogito*, etc. In effect . . . it is exactly as if the astronomers, without having proceeded from any previous observations, posed hypotheses from which would be deduced whatever true observation.<sup>51</sup>

It is insufficient that the hypotheses we formulate not be wholly fictional; they must resemble the truth. At least astronomers—and by implication, anyone exploring the nature of the world with like rigor—adopt causal hypotheses (to explain, for example, planetary positions) which they think resemble the truth on the supposition that such hypotheses may actually describe the real structure of the world. Yet they may well not describe that structure accurately. Accordingly, Gassendi refrains from identifying truth *per se* as the criterion for accepting hypotheses.

This much is consonant with a somewhat pessimistic variant of MEA, namely, that our perceptual grasp of that real structure could be sufficiently poor that any number of hypotheses might more or less conform with what we crudely perceive. Indeed, we find hints of this variant in Gassendi's *Philosophiae Epicuri Syntagma*—the 'little Syntagma'—a work which largely rehearses Epicurus's views (though always in his own voice and with careful attention to those areas in need of 'correction'). Here Gassendi initially suggests we might have a number of empirically adequate hypotheses in astronomy, and contrasts this situation with that of basic physics, where the best hypothesis is the one which ". . . agrees in but one way with appearances."<sup>52</sup> In either case, though, empirical adequacy appears to be a foremost

<sup>51</sup> O III (*DM*) 283b; R 54.

<sup>52</sup> O III (*Syntagma Philosophiae Epicuri*) 53a. The difference between astronomy and physics in this context apparently follows from the distinctive strategy for choosing among astronomical hypotheses. If we did not say there could be more than one viable scientific hypothesis in astronomy, and that hypothesis failed, we would be tempted to fall back on a theological account. But this would be accepting that there are different, equally plausible ways to understand astronomy, including appeals to faith as well as experience or reason, and yet—at least by scientific lights—there should only be one way, which is not primarily or originally theological. To prevent us from falling into temptation, Gassendi proposes, we can simply allow that if an hypothesis fits the data, that is enough for us to embrace it, recognizing that this may lead us to embrace more than one candidate. This point conforms with a classical Epicurean account; q.v. note 63, below.

concern. Further, in the passage from the *Disquisitio* just cited, he claims that scientists pick just the hypotheses they believe to be truth-resembling on the grounds that, if there were any others they believed to be ‘more probable’, they would have picked them. This suggests that scientists judge among hypotheses by choosing those that most *closely* resemble the truth. From this suggestion it might be supposed that we can measure verisimilitude by mere empirical adequacy, but Gassendi has a richer sense of what is adequate here than what is suggested by MEA, at least in its classical form.

Specifically, in a subsequent passage in the little *Syntagma*, he proposes that the lone mark of acceptable hypotheses cannot be that they save appearances, for we also need to save the non-apparent phenomena we learn about from signs:

It is necessary . . . to draw conjectures as to what takes place in the heavens from those things which go on about us, from those things about us, I say, which are observed as fact and those things to be seen in the heavens.<sup>53</sup>

Further, insofar as we build our hypothetical explanations on elements of this expanded range of empirical evidence, we should judge those explanations as acceptable or not on the same basis. He pleads for a method where our reasoning about hypotheses in astronomy taps such an expanded range:

. . . let it not be that the entire line of reasoning with regard to the causes of celestial phenomena be invalidated, as has happened when many have embraced an impossible theory, becoming lost in their vanity, and have tried but one approach and abandoned all others even though these are possible, being carried off to dream what the intellect knows better of, and not admitting to their reasoning things as they appear and things that are properly signs. . . .<sup>54</sup>

In general, we should judge a given hypothesis to have greater verisimilitude than any of its competitors on the basis of the full breadth of our experience and the way we interpret it—and not simply what is contingently, currently perceptible or what our *a priori*

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It is not clear, though, that Gassendi takes this to represent anything other than the strictly classical Epicurean perspective. Below, I discuss his own, distinctive view that even in astronomy some hypotheses should turn out to be more truth-resembling, hence more preferable, than others.

<sup>53</sup> O III (*Syntagma Philosophiae Epicuri*) 53a.

<sup>54</sup> O III (*Syntagma Philosophiae Epicuri*) 57b.

intuitions suggest. If our best empirical evidence includes that which we cull from signs, then this is to be counted as well as any other confirming information. Though Gassendi restricts our best judgments of hypotheses to saying they may be no more than truth-resembling, he also offers a liberal view of what counts as admissible evidence to suggest such resemblance.

In sum, Gassendi stands apart from both those who say that (a) because we devise hypotheses on an intuitive, non-experiential basis, we should judge them as true just in case those intuitions are indubitable, and those who say that (b) though we cannot know our hypotheses to be true, we judge them as empirically adequate if they save the appearances (and, following Descartes, if they agree with our basic metaphysical and physical principles). For one, Gassendi holds that we have neither an intuitive nor a non-experiential basis for devising hypotheses, and so he dispenses with the traditional grounds for thinking they may be indubitable. Further, the range of viable evidence extends the range of our claims beyond notions about what is perceptually given, so neither can we judge hypotheses as acceptable simply if they are merely empirically adequate in the classical sense. Rather, we need to draw on a full range of evidentiary support encompassing evidence from signs to gauge whether candidate hypotheses more or less closely resemble the truth. It is the hope of Galileo and Descartes that we make this conjectural element of science conform with, if not bear the very mark of, our certain knowledge. This hope may seem misguided by the light of present day thinking but is perhaps explained by a romance with the general mathematization of empirical inquiry, at the cusp of modern probability. That Gassendi, for his part, insists on no such thing is consistent with his empiricist suspicions of knowledge with certainty.

#### 4. *Empiricist Difficulties of Gassendi's View*

Empiricist suspicions unfortunately tend to be double-edged, and Gassendi does not readily escape this tendency. For example, if evidence from signs is to count as support for hypotheses about the nonevident, one might well think it appropriate to say hypotheses so supported do not resemble the truth as much as they bear a

resemblance to our best understanding of the perceptual data, in accordance with our interpretations of and information provided by, signs. Here, I focus on three other problems Gassendi's method of hypothesis faces, as an empiricist perspective: that his method conflicts with a traditional view of hypotheses, that what we report from experience should turn out to be knowable with certainty (given that they follow with necessity from the hypotheses we accept); that verisimilitude provides an apparently weak guide to judging between competing hypotheses; and that it is unclear how to attain satisfactory evidence for hypotheses about future events.

*The traditional view of hypotheses.* To begin with, in good empiricist form, Gassendi rejects a traditionally-held rule—promoted, for example, by Descartes—that for all experientially-based claims we make given a particular set of hypotheses, we should be able to deduce them from said hypotheses. This rule, at the core of the orthodox 'save the phenomena' view, rests on the notion that such claims may follow *with necessity* from the hypotheses. If so, and if the hypotheses themselves can be shown to be necessary, then the empirical claims deduced from them should be knowable with certainty. The idea is that necessity of a given set of propositions (or inferential relations of such) confers certainty on our knowledge of the same.<sup>55</sup> One major problem for this rule follows on a classical empiricist distinction between certain knowledge (*episteme*) and probable *opinio* (*doxe*), according to which empirical claims are the stuff of the latter, not the former. Gassendi, as we have seen, views all fields of study—from geology to geometry, save theology and theological cosmology—as empirical endeavors and so proposes that the claims we make in such studies are merely probable. So on his view either this classical distinction is somehow wrong, or else the orthodox 'save the phenomena' view went astray somewhere. By the lights of mature modern empiricism—of Locke or Hume, for example—the classical distinction is wrong: whatever division there is between knowledge and opinion is not marked by certainty or the lack thereof. While Gassendi anticipates some form of this idea, it is not what deters him from

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<sup>55</sup> This orthodox view is separable from the epistemic theses to which it is so frequently attached in discussions of the 'save the phenomena' view, for example, with respect to knowability or, as I suggest above, truth.

holding that, given that we derive experientially-based claims from accepted hypotheses, those claims may be certain. What deters him from holding this last notion is his distinctive variant of the ‘save the phenomena’ view, which does not invoke the traditional rule of the orthodox view. That view is wrong at a more basic level, in his conception, for claims about appearances need not follow as necessary consequences of the hypotheses we accept. Hence even if the rule was viable, it has no place here, and certainty about our empirical claims need not follow.

This last suggestion may seem as though it should have been difficult for Gassendi to articulate. After all, he was acutely aware that, in the long tradition in astronomy of saving the phenomena, previous astronomers crafted their hypothetical pictures of the world in such a way as to account for all currently available data. They further held that future observation reports should follow from these hypotheses.<sup>56</sup> Yet Gassendi does not deny this consequence relation; he denies that it must be an inherently necessary one. We should rather fix the degree to which our hypotheses’ consequences are necessary, he claims, to the extent of their utility in our scientific reasoning. We find this suggestion in his letter to Jacques LeTenneur of May, 1649 (appended to LeTenneur’s *De Motu Naturaliter Accelerato*). Here he praises LeTenneur for, among other things, proposing a theory of time similar to his own and recognizing that even a false theory of time may yield a picture of actual temporal phenomena we think is true. He writes:

There could not be anything better to say than what you advance concerning these false hypotheses, from which we draw true consequences . . . to want to extend the thing [schema] to nature as well as practice—[that] this is to not understand that nature only goes by its own ways, which are always directed from the cause towards its effect, as from what precedes towards what follows, with necessity. And [to not understand] that hypotheses are purely works of human understanding, which forges them for its convenience such that their consequences can depend on them with the necessity that the understanding desires.<sup>57</sup>

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<sup>56</sup> Q.v. his discussions of the contending Ptolemaic, Copernican, and Tychean astronomical hypotheses, in *O IV (Institutio Astronomica)* 25a–45b; 46a–55a; and 60b–64a.

<sup>57</sup> “Lettre de Monsieur Gassendi à l’Auteur”, in *De Motu Naturaliter Accelerato Tractatus Physico-Mathematicus in quo Discussis, Aliquot Recentiorum Sententiis, Vera Accelerationis*

In this compressed series of thoughts, Gassendi first allows that we may draw true consequences from false hypotheses, regardless of whether we know them to be false. The alternative he rejects—perhaps styled after Descartes’s view—is that we could only draw true consequences from hypotheses we already knew to be true. That alternative is indeed unlikely, given that hypotheses are essentially conjectural or speculative. On the other hand, one might think this first piece of Gassendi’s proposal fares no better, for it apparently entails accepting cases where, no matter how attractive its true consequences, the falsity of the hypothesis is stark and hard to swallow. So, for example, the particular case Gassendi addresses in this passage concerns a false hypothesis about the nature of time, which suggests the direction of causality need not go from precedent to consequent events.<sup>58</sup> If we subscribed to such an hypothesis (false though it might turn out), we would have sufficient reason to believe that what we take to be its true consequences must follow from it. This much is a trivial restatement of the consequence relationship. Of course, the hypothesis in question turns out to be false: nature’s path is only from cause to effect, with a physical or theological necessity, over which we have no say. Although it seems fair to suggest that the consequences of that hypothesis (or any other) might be true, the implausibility of the hypothesis itself does not recommend our acceptance. Nor does it recommend our rejection, though, as its consequences go—and that more distinctive point is Gassendi’s.

In any case, Gassendi’s next, quite curious move is aimed squarely at establishing that we *should* have a say in the degrees of necessity governing the projected consequences  $c_1, \dots, c_n$  of a given hypothesis  $h$  (that is, the probability for all  $c/h$ ). His reasoning is that we only fashion hypotheses to begin with given their utility or ‘convenience’ (as he puts it) in grasping the nature of the world. It is open to us, should we deem it useful for promoting an hypothesis (in which we have independent interests) to judge it less than necessary. Thus, in the case that Gassendi considers, we might think it merely probable that particularly untoward characterizations of our actual temporal

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*Gravium Ratio Demonstratur*, Jacques-Alexandre LeTenneur (Paris: Louis Boulenger, 1649), 140–141.

<sup>58</sup> This approach might be attractive to LeTenneur’s Scholastic opponents, given their suggestion that the duration of all events is to be considered as a whole occurring all at once.

data follow from whatever conjectures we offer about the nature of time. In sum, his suggestion—much in the spirit of his ‘probabilist’ view of empirical demonstration—is that our present and future reports of observations and other data need not follow with necessity from our hypotheses, except and insofar as our understanding (the mental faculty of assembling ideas) requires it. Quite apart from this suggestion, we must insure that such data reports *conform* with our hypotheses, or else there is something wrong with our hypotheses, namely, that they fail to save the appearances. But that such reports, justly seen as consequences of the hypotheses, follow them with *one or another degree* of necessity is simply a matter of utility or convenience. By dismissing the prevailing alternative (that the data reports we generate are perforce necessary, as consequences of the set of accepted hypotheses), Gassendi hopes to escape what is for him the attendant repugnant conclusion that, in principle, we should then be able to know such empirical claims with certainty.<sup>59</sup>

To avoid that conclusion, though, there is actually a far simpler route. In short, Gassendi worries for naught: that something is necessary does not guarantee that we are able to know it with certainty. Moreover, while it is correct that we need not consider our data reports as necessary just in case they follow necessarily from our background set of hypotheses, this is rather because we are not obliged to fix the hypotheses themselves as necessary. So while it is intriguing to suggest that we fix the conditional probability of our data reports given the hypotheses we accept to the utility of those hypotheses, for Gassendi’s own theoretical purposes it is not necessary to pursue such intrigue. As he points out in his own account of deductive inference, we have merely probable conclusions if we start with merely probable premises.

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<sup>59</sup> An alternate reading of the letter to LeTenneur is that the understanding *always* requires necessity, and it is convenient that the mind invents hypotheses endowed with such necessity. Yet this reading suggests that the connection of ideas in the understanding need not be a contingent affair, and Gassendi offers no support for that view (indeed, his general theory of mind suggests the opposite view). Moreover, he has ample opportunity in the *Institutio Logica* and elsewhere to endow inference rules with necessity and fails to do so, even in his account of demonstrative reasoning. One may infer that he did not readily link inference with necessity, in general.



*Verisimilitude as a weak guide*

Further problems arise out of identifying verisimilitude as the mark of approvable hypotheses. For one, Gassendi does not specify exactly why we might count one hypothesis or another as more or less truth-resembling. Here he skirts the classic difficulty of verisimilitude: if we knew exactly what it is like to for something to resemble the truth we should have had some idea of what the truth itself is. In that case, we might as well hold hypotheses up to that standard and not settle for resemblance to the truth. One response to this—which would align Gassendi with Peirce—might be to say that we cannot be sure we know what the truth of the matter will turn out to be, and so the cautious move is to simply call our standard ‘resemblance to the truth’. This is a fair reading of Gassendi’s conviction that the truth of matters is elusive yet we have sustainable beliefs about the world. But that response is unsatisfying, for it fails to distinguish between resembling a truth of which we are sure and resembling one of which we are uncertain. For instance, we may be certain that  $3.1 = \sqrt{9}$  resembles, in a sense, that  $3 = \sqrt{9}$ , but rather uncertain that ‘Arcesilaus preceded Pyrrho’ resembles that ‘Academic skepticism preceded Pyrrhonian skepticism’. Of course, there cannot be any such difference for Gassendi because he proposes that there are *no* truths of which we may be absolutely certain.

A different sort of problem with verisimilitude is that it does not always enable us to pick out a uniquely acceptable hypothesis. If, for example, several competing hypotheses resemble the truth to the same degree, it is a mystery as to how we should judge between them. Gassendi himself proposes that such a scenario could arise. According to the Skeptics, he points out, given a set of hypotheses that successfully predict some apparent phenomena, we may need to judge between competing hypotheses with the same empirical consequences: “. . . the same appearances could be predicted and preserved by contrary hypotheses which could not be true at the same time as the first.”<sup>60</sup> He follows the Skeptics in this regard when he

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<sup>60</sup> *O* III (*DM*) 384a; *R* 510; *B* 265. In this passage Gassendi defends the skeptics against Descartes’s view that they would doubt geometrical demonstrations—unless they grasped the existence of God, the ultimate epistemic guarantor. Gassendi replies that the skeptics actually accepted geometrical claims in the same *de facto* way that they accepted appearances. What they objected to, by contrast, was the geometer’s and astronomer’s excessive confidence and manner of proof.

suggests that the distinct astronomical hypotheses of Tycho Brahe and Copernicus may account for the same celestial observations, though they cite incompatible causal events (the Copernican view being superior in virtue of being ‘clearer and more elegant’ than the Tychean view).<sup>61</sup> Thus Gassendi’s verisimilitude view differs not at all from the classical MEA view, in that the approval of one hypothesis over its competitors may be underdetermined by the empirical evidence. This was bound to be the case, perhaps, so long as his view only differed from MEA by more broadly construing what we should count as empirical evidence. In the contemporary philosophical landscape, we might not even find this underdetermination to be a terribly uncomfortable result if, for example, we share Quine’s assessment that we can easily enough pick out the group of mutually supporting hypotheses which best accounts for our empirical data without overriding simplicity and conservatism constraints. If this was Gassendi’s view, there would surely be an additional, theological constraint to avoid overriding. It is not clear, though, that he offers anything as substantive as the holism of Quine’s account. Moreover, while he occasionally refers to what the Church prefers or what must be denied in order to conform with Providence, he never quite identifies theological constraints—or any others—as additional *scientific* guidelines for choosing among empirically underdetermined hypotheses.<sup>62</sup> If he remained true to the near-Pyrrhonism of his earliest work, we might expect him to say that we just suspend our judgment in such cases. However, the mature Gassendi—who abandons the Skepticist ideal of *ataraxia*—follows a more Epicurean path here, simply leaving us without directions for picking out the worthier of any two equally truth-resembling hypotheses.<sup>63</sup>

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<sup>61</sup> *O* I 145a; on Gassendi’s rejection of Copernicanism, in line with Church teachings, q.v. also *O* III (MI) 519a–b; *B* 147–149. Although this hypothesis ‘pluralism’ may seem like a novel, modern stance on Gassendi’s part, in fact he is embracing Epicurus’s view that multiple hypotheses may satisfy the phenomena, including in particular celestial events; q.v. *Her* 78–80; *Pyth* 86–88, 113; Asmis (1984), 321–322.

<sup>62</sup> Gassendi and his contemporaries typically did not distinguish between science and religion in the ways now familiar to us, and most of them allowed for a great influence of what we think of as the latter on what we think of as the former. However, they generally did not have trouble identifying some claims as belonging to the one or the other—indeed, Gassendi was probably closer to holding our modern distinction than most of his contemporaries. Bloch (1971) stresses this point, perhaps to the partial neglect of Gassendi’s commitments to viewing the world as Divine Creation.

<sup>63</sup> For Epicurus, there is no rational means of choosing among such multiple

*Hypotheses and future events*

Finally, a third empiricist-inspired worry is that Gassendi endorses the use of hypotheses as tools for predicting future phenomena—which appears to suggest that hypotheses constitute a source of epistemic judgments beyond what is warranted by the senses. In his own writings on astronomy he prominently draws on the predictive use of hypothetical reasoning, typically building conjectures about future planetary motions on the basis of hypotheses concerning planetary motions, constructed in turn on the basis of observational reports. While we may draw on those past reports as empirical grounds for such hypotheses, the content of our conjectures concerns phenomena which have not even occurred and so are unavailable to our senses. Given a strict insistence on the sensory basis of warrant for our hypotheses, there should not be much evidence we can muster to justify initially entertaining, let alone accepting, hypotheses about such future phenomena. Moreover, lacking sensory acquaintance with the future, we cannot even bar bad predictions about such phenomena on the grounds that they fail an empirical adequacy test.<sup>64</sup> Two lines of Gassendi's reasoning suggest responses here. For one, we might believe future data will bear out our conjectures on the basis of our present and past successes in accounting for the current data. This does not get us very far since we may then wonder why we should take those past successes as evidence of future success. Alternatively, the theory of signs suggests we are justified in accepting inferences from claims about the evident to claims about the nonevident just in case we cannot otherwise explain the former claims. Then reasoning by hypothesis about the future (either by analogy, or direct appeal, to sign-based inference) looks acceptable whenever

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explanations. As Asmis notes, Lucretius goes even further, proposing that some events or phenomena bear multiple explanations because they have irreducibly multiple causes, owing to our distance from the cause. Here he appears to conflate epistemic access and metaphysical possibility; q.v. Lucretius, *RN* 5.526–533; Asmis (1984), 324–325.

<sup>64</sup> Of course, we might judge between them in advance of the events they predict, on other grounds. Gassendi himself does this insofar as he embraces Kepler's picture of planetary motion even before he observes the passage of Mercury before the sun, and declares this sighting to be sufficient evidence for approving the Keplerian picture over its competitors. But then empirical adequacy relative to future events is not only not the *lone* test of approving an hypothetical view, it may not even be the *crucial* test.

we have no better way to account for the current data. This suggestion raises a different question, however: why should we think there is no better way to account for the data if they are not all available, that is, given that the conjectured phenomena have not yet occurred? Perhaps the best we can say here is that Gassendi is in the good company of others who promote this brand of inference to the best explanation. In chapter thirteen, I take a closer look at his approach to this sort of inference strategy.

### *Conclusion to Part II*

Its serious difficulties notwithstanding, Gassendi's method of hypothesis is a remarkable historical development. It offers not only an alternative to the foundationalism of Descartes and Galileo or the inductivism of Bacon<sup>65</sup> but also an advance over his own *Institutio* view. While Gassendi makes some brief suggestions regarding science's conjectural element in the *Institutio*, there he largely follows Epicurus's project of outlining acceptable modes of inference. Further, in focusing on fitting all scientific method to a variant of Aristotelian demonstrative syllogism, he neglects to account for reasoning from hypotheses. However, as we have seen, Gassendi elsewhere develops a method of hypothesis which borrows as well from those classical sources, representing a steady progression from his Epicurean and Pyrrhonist inspired theory of empirical knowledge.

For example, the suggestion that we initially consider only those hypotheses that account for reports of data from experiment and observation is undoubtedly modeled on the Epicurean proposal that whatever we can hope to know is based on ideas from the senses. Further, the notion that empirical hypotheses may resemble the truth just in case they match our perceptual data echoes the Epicurean concern that our concepts of nature match information from the senses. On the other hand, his empiricist proposal that we entertain just those hypotheses founded on ideas of appearances is shaped by constraints of a Pyrrhonist order: such hypotheses represent no more than probable conjecture given that we cannot be certain about the claims we base on such ideas. There is at least one place where

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<sup>65</sup> Or, at any rate, the historical caricatures thereof.

Pyrrhonism and Epicureanism alike influence his view: he proposes that hypotheses are acceptable just in case they best resemble the truth, since we cannot hold them up to the standard of truth *per se*. This reflects the ancient view that we may be epistemically acquainted only with appearances and not with the way things truly and essentially are. All these aspects of his method of hypothesis, quite unaccidentally, recapitulate elements of his theory of empirical knowledge: as we have seen, his notion of natural science is effectively that of an enterprise to gain empirical knowledge of the world, which exercise is bound by his empiricist model. In this vein, perhaps the most significant aspect of Gassendi's rehearsing general epistemology in the specifically scientific context is his notion of what counts as support for an empirical hypothesis, the product of his background Epicurean sign-theoretic conception of evidence.

We see a different sort of picture in the *Institutio*, where Gassendi does not ground method in such elements of Epicureanism or Pyrrhonism. There, he instead follows loosely a *regressus* model—most closely linked (a lack of overt reference notwithstanding) to the Renaissance Paduan method. In his version, we see an attempt to assimilate demonstrative syllogism to procedures of empirical inquiry such as discovery and justification. According to his *regressus* model, crafting such demonstrations entails seeking knowledge of causes from effects, or else effects from causes—where demonstrations of one kind follow the inverse sequence of steps taken in demonstrations of the other kind. Alas, such composition and resolution schemata do not work as Gassendi intends. Yet his *regressus* method allows, reasonably enough, that we may characterize empirical demonstration as probabilistic (albeit according to a nonstandard sense of 'probabilistic'), and suggests the principal difficulty of ampliative inferences, including classical ampliative induction. This *Institutio* account falls short because Gassendi cannot guarantee that resolute and compositive schemata successfully mirror one another, and because he fails to see that the sort of 'probabilist' demonstrations he licenses incorporate ampliative inferences. He thereby generates in a new guise the same puzzles he worries about relative to our lacking the generalizing steps necessary for warranting such inferences. Nowhere are these shortcomings clearer than in his actual scientific writings, where his experimental and observational accounts indeed reflect some effort to adhere to a *regressus* method. Such accounts also highlight the blanket failure of the *Institutio* method to provide guidelines for empirical reasoning by hypothesis.

One element of Gassendi's method we have not yet touched on is his proposed overall means of theory choice. An important aspect of that proposal is his view on the accuracy or verity of hypotheses, a *via media* perspective suggesting that the hypotheses of choice approximate the truth. Yet this view does not necessarily tell us *how* we chose among theories given a set of viable alternatives; a range of hypotheses might fulfill that criterion, more or less. We have seen bits and pieces of Gassendi's perspective on this issue—that we make use of some form of inference to the best explanation—which view I look at in closer detail in chapters thirteen and fourteen.<sup>66</sup>

What links these varied elements of Gassendi's method is a concern with how to meaningfully address the non-evident in the natural sciences. On the expansive side, this very Epicurean concern, we have seen, leads him to a method of hypothesis which, given his theory of signs, permits conjectures about the non-evident that we can still consider as empirical claims. But this same concern, on a conservative side, inspires as well his 'probabilistic' characterization of demonstrative proofs based on premises the truth of which is not apparent. It also spurs his worries about claims said to follow ampliative inferences, where again our limited ability to know about the nonevident severely constricts what we think our proofs and inferences can tell us about the world. At once we find an optimism about, and suspicion of, claims about the non-evident founded on our experience of the evident. This discordant mix suggests his method features two objectives that are *prima facie* difficult to reconcile: meeting maximal empiricist constraints and granting liberal license to conjectural reasoning.

Gassendi's intent at attaining both objectives can be glimpsed in his writings on physics and other elements of natural philosophy where, to a degree, he applies tenets of his scientific method and

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<sup>66</sup> It may be tempting to conclude at this stage, given Gassendi's interests in hypothetical reasoning, and his account of deductive reasoning, that he maintains some form of hypothetico-deductivist (HD) approach here; this is the conclusion reached by Detel (1974). Yet whatever Gassendi has on offer as regards theory choice is clearly not any classical form of HD. As we see in chapter thirteen, his view rather approximates IBE, drawing as well on more traditional inductive strategies. This is what we should expect, given Gassendi's empiricist probabilist view. Indeed, Detel claims that Gassendi cannot be a typical empiricist because of his true deductivism—and as we have seen, a simple response here is that Gassendi's empiricism governs his notion of deductivism.

theory of empirical knowledge. As we have seen, he takes these tenets as partial guides to his conception and conduct of empirical research in his report on the Puy-de-Dôme experiments. Yet the most significant indication of how seriously he takes these tenets—and how he might resolve tensions between his empiricism and ambitions to justify claims about the non-evident—is revealed by the character of Gassendi's atomist hypothesis and the degree to which his atomism conforms to his method. In this context, he addresses enduring problems, which plagued earlier atomists and, later on, come to trouble Boyle and Locke. First, where hypotheses about the nonevident are proscribed by strong empiricist commitments, special justification should be offered on behalf of conjectural corpuscularian arguments. Second, such justification for this bit of hypothetical reasoning may consist in the explanatory power of corpuscularian matter theory, as part of a general mechanical philosophy. An additional issue is whether such explanatory power can be translated as empiricist warrant.

The atomist hypothesis, it turns out, provides a particularly good test of Gassendi's empiricism. Given the prominence of atomism in his physics and numerous other accounts of the natural world (save for the astronomy, where atomism plays a small role), its hypothetical status constitutes a major challenge for the view that a secure science rests on warranted beliefs based on information from the senses alone. The challenge is that micro-entities to which this hypothesis commits us are not the subject of such warranted beliefs, at least in the era preceding modern developments in microscopy. His response is to refer us to sign-based inference as the means of arriving at hypothetical claims about micro-phenomena which underlie macro-phenomena. As I argue in the chapters ahead, an important part of Gassendi's strategy is to seek empirical evidence through signs for provisionally adopting an atomist picture. However promising this strategy, a number of puzzles remain, as to how such macro-phenomenal signs should or could be read as support for this hypothesis.

One further question is whether Gassendi's development and use of an atomist hypothesis is paradigmatic of, or else exceptional to, his views on empirical knowledge and scientific method. I suggest in Parts III and IV that this hypothesis is more exemplary of, then exceptional to, those views, but that there are significant limits on what sorts of claims we might expect from sign-based inference and conjectural hypotheses in Gassendi's maximally-empiricist science.

For example, the atomist proposal that the microworld resembles, and operates similarly to, the macroworld, raises the question of how we might come to think that there are such relations as resemblances or similarities holding between the perceived and the unperceived. We should wonder not only about evidence for those particular relations, but as well about the sorts of relations our accepted physical and logical constraints allow us to build into such conjectures in the first place. As I indicate in Part III, Gassendi is sufficiently concerned with such constraints to discuss and promote them yet not sufficiently interested to allow them to shape his atomist matter theory.



PART III

THE ATOMIST HYPOTHESIS



## CHAPTER SEVEN

### SMALLEST PARTICLES: FROM ANCIENT ATOMIST AND *MINIMA* THEORIES TO *MINIMA NATURAE* AND PHYSICAL CORPUSCULARIANISM

As a first step in advancing the empirically knowable element of his general physics, Gassendi introduces a basic and core ontological thesis—atomism. He tenders this thesis as an alternative to contending matter theories of his day yet makes no pretense as to its novelty. Rather, he openly follows a long tradition of views that include classical atomism and the related *minima naturalia* theories of non-atomist scholastics. The central claims of his atomism most closely resemble claims found in Epicurus and Lucretius: that there are two sorts of extended things—atoms (the basic constituent elements of matter) and void, that matter cannot be physically divided beyond a particular minimal component which itself has no parts (atoms), and that everything is composed of some combination of void and those elemental components of matter. To construct his physics, Gassendi is particularly concerned with the ancient suggestion that all macro-sized properties and phenomena are the product of the combinations and actions of matter's ultimate parts. He adds this ontology to his mechanical world picture, in the hope that it may yield at least adequate, and perhaps truth-resembling, accounts of physical phenomena. One constraint on attaining such accounts is that his atomism should be consonant with other elements of his mechanical philosophy. But Gassendi's empiricism imposes an additional constraint on this task—which marks him as among the first modern atomists: since these atomist claims are at the core of his physics and so constitute empirical knowledge, they should be largely if not wholly derived from sensory data.

Gassendi has mixed results in accommodating both constraints. His atomism sustains a picture of the world where all action is by the contact of one body with another. Yet that atomism fails to wholly satisfy the tenets of the mechanical philosophy, most notably because it violates his own principle of inertial motion—which he holds as ranging over the motion of all bodies, no matter their size.

With respect to the empirical grounding of Gassendi's atomism, all the evidence he adduces for that hypothesis is at best indirectly the product of sensory data from observation or experiment. While this might not satisfy the strongest empiricist perspective, Gassendi holds that such a means of gathering and inferring from the available evidence, as warranted by sign-based inference, suffices for saying atomism is justified on empirical grounds.

Little of Gassendi's concerns with atomism's relations to laws of motion or warrant for evidence of subperceptibles is found in most of his atomist or other corpuscularian predecessors.<sup>1</sup> Many strands of his atomism, however, directly borrow from previous thinkers, or else are formulated in response to them. Thus, one prominent tenet of Gassendi's physics—broadly shared in the new science of the early modern era—is the view that we best account for the nature of matter and the manifest qualities of familiar mid-sized material objects by postulating subvisible basic elemental particles from which all such objects are constituted. This corpuscular matter theory incorporates elements of two competing ancient perspectives: the atomism promoted by Leucippus (fifth century BCE), Democritus (460–370 BCE), Epicurus (341–270 BCE), and Lucretius (100–55 BCE), among others, and the theory of *minima naturalia* inspired by Aristotle's decidedly non-atomist picture of smallest physical parts. By the time this sort of view gains wide currency among seventeenth century thinkers, though, a great many antique and early modern corpuscularian theorists had proposed particulate views of matter as foundational in

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<sup>1</sup> On earlier and competing views of atomic motion—which tend to a less-well formulated normativity—q.v. John Murdoch, “Atomism and Motion in the Fourteenth Century”, in *Transformation and Tradition in the Sciences: Essays in Honor of I.B. Cohen*, ed. Everett Mendelsohn (Cambridge; New York: Cambridge University Press, 1984), 44–66; and A. George Molland, “The Atomization of Motion: A Facet of the Scientific Revolution”, *Studies in the History and Philosophy of Science* 13 (1982), 31–54.

Evidence for subperceptibles is much discussed as early as Lucretius (q.v. Christoph Meinel, “Early Seventeenth-Century Atomism: Theory, Epistemology, and Insufficiency of Experiment”, *Isis* 79 (1988), 68–103) but the *warrant* for such evidence is not much debated in relation to atomism. The theory of signs is widely discussed by the ancients, but there is little suggestion of it being central to our grasp of or support for corpuscularian or atomist matter theories. Only with the Epicurean theory of signs are the possibilities regarding atomism's empirical confirmation explored—thus Philodemus appeals to indestructibility of bodies we experience to commend the general indestructibility of matter, which is vested in atoms (q.v. *De Signis* 17.37–18.3; Asmis, (1984), 259). Upon these slender threads Gassendi develops his views.

physics and metaphysics. This is a vast history, though, and to best grasp the roots of Gassendi's views, it is necessary to focus on the genesis and development of Epicurean atomism and closely related doctrines.<sup>2</sup>

Much of what unites the ancient atomists—even prior to Epicurus—is articulated early on, by Leucippus and Democritus,<sup>3</sup> who attempt to explain the persistence, change, and manifest qualities of material objects, by the shape, arrangement, position, and interactions of their unchanging and indivisible constituent elemental particles.<sup>4</sup> There are infinitely many atoms moving constantly, *ad infinitum*, through a void of infinite expanse.<sup>5</sup> Atoms themselves lack any internal void and so are wholly solid. Thus when atoms collide, one cannot invade the space of another. Instead, they either bounce off one another or else come together to form aggregates, cohering by means of mutually fitting protrusions or mutual pressure. Out of such aggregates mid-sized objects as well as the Earth, heavenly bodies, and the vortices which generate and transport them are all constituted. Although atoms themselves are of homogeneous composition, they differ in shape and size and, since they are all of the same stuff—with constant density—they differ in weight, too. These atomic qualities do

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<sup>2</sup> The history of atomism and other matter theories is yet vaster than that of the Epicurean tradition or even that of its strictly atomist cousins. I cannot pretend to cover the entirety of that history, even in outline. Recent overviews include Pyle (1995), Bernard Pullman, *The Atom in the History of Human Thought*, trans. Axel Reisinger (Oxford: Oxford University Press, 1998), and the rich essays in Christoph Lüthy, John E. Murdoch, and William R. Newman (eds.), *Late Medieval and Early Modern Corpuscular Matter Theories* (Leiden: Brill, 2001); an earlier synoptic account is Kurd Lasswitz, *Geschichte der Atomistik vom Mittelalter bis Newton* (Hamburg and Leipzig: L. Voss, 1890).

<sup>3</sup> Sources for Leucippus include *DL IX 31* and Aristotle, *De Gen A §8*. Sources for Democritus are more plentiful and varied, but some important ones include: *DL IX 34 f.*; Simplicius, *De Caelo 293* and *Physicorum 28 §15*; Galen, *De Elementis I 2*; Theophrastus, *De Causis VI §1.6* and *7.2*, and *De Sensu §49 ff.*

<sup>4</sup> One prominent goal of the early atomists is a reconciliation of the Heraclitean claim that change is everywhere in the world with the Parmenidean claim that change is impossible (because whatever is, is; whatever is not, is not; and nothing passes from one to the other). Blending elements of these claims, they suggest something does exist without change for all eternity—the constituent particles of all matter—and it is just the nature and behavior of these particles that accounts for all apparent change.

<sup>5</sup> Epicurus differs here in suggesting that, while there are indenumerably many atoms, there are not infinitely many (*Her 42*).

not however change over time; otherwise atoms would lose the stability that contributes to their status as basic particles of matter.<sup>6</sup>

These claims were offered—or at a minimum, only survive—without the benefit of underlying argument, such that Epicurus's chief advance beyond Leucippus and Democritus is his development of what has come to be recognized as the canonical reasoning for the primary atomist tenets. Those tenets include the propositions that it is metaphysically necessary and empirically supportable that (i) the basic particles of all matter are indivisible and (ii) describing the nature and behavior of such particles suffices to account for all qualities of familiar macro-sized objects. Specifically, for example, in his *Letter to Herodotus* (*DL X* 35–83) Epicurus argues that atoms must exist if we give credence to the Parmenidean claim that nothing comes from or passes into nothing. Further, we have empirical evidence for an atomist picture of the world, given that we can infer from sensory perceptions that there are such things as atoms (with their attendant qualities)—not by having sensed them directly but instead interpreting what we perceive as signs of the same. Even if we do not experience atoms first-hand, atomism provides our only satisfactory account of phenomena we can experience.

Epicurus first proposes that perceptual data provides compelling evidence for the existence of bodies as well as their motion and transformation,<sup>7</sup> and next, that these claims oblige us to accept the picture of bodies as composed of atoms, or the smallest bodies, in motion.<sup>8</sup> This last bit of reasoning is as follows: If we perceive bodies in motion or undergoing changes, it must be because some of them have parts and others *are* such parts, and the latter kind must be indestructible or else they would not persist through change and dissolution of composites. But we know something persists through such changes among mid-sized objects, because whatever remains there after changes occur did not emerge from nothing; the underlying principle is that no thing comes from or passes into what does not exist. Indeed, to speak intelligibly of change in a given mid-sized object, there must be something which maintains its identity throughout such change, otherwise there is no way to assign change to one and the same object. We can only have this identity if some ele-

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<sup>6</sup> Q.v. Lucretius *RN* I 540–83, 665–74; Asmis (1984), 253–254.

<sup>7</sup> *DL X* 39–40.

<sup>8</sup> *DL X* 41.

ments or parts of the object persist throughout. These parts that persist through those changes, Epicurus stipulates, are simply those indivisible bodies we call ‘atoms’.<sup>9</sup>

One troublesome move by Epicurus is his appeal to the Parmenidean claim that nothing comes from or passes into nothing. He does not bother to suggest why we should think this true, nor why we must rely on it to explain the persistence of material bodies through change. If we knew, as Epicurus hints, that change involves interaction of matter only, we might reasonably infer that any change involves material bodies at its beginning and end, so that whatever persists through change must consist in some sort of matter which is indestructible. But this invites the question as to why change must involve interaction of matter only—as against, for example, alterations in the nature of matter—and the only ready answer seems to be that *nihil ex nihilo*, by fiat.

Beyond crafting such arguments for the mere existence of atoms, Epicurus expands upon the basic model of the earlier atomists—that there must be void through which bodies may move, there is an infinite number of atoms, and atoms differ in shape and size. He adds various and occasionally divergent details, such as that there are not infinitely-many kinds of atoms, and the total number of bodies is somehow constant.<sup>10</sup> His most notable elaboration of earlier views, though, is his account of atomic motion—a chief component of his micro-phenomenal account of macro-phenomenal change.<sup>11</sup> Although the better part of this account simply echoes Democritus and Leucippus, he also suggests that the ever-present motion of atoms is a consequence of their ever-present tendency to fall downward given their inherent weight.<sup>12</sup>

That the weight of atoms is fixed, and contributes to their constant motion, yields a few characteristic results, according to Epicurus. For example, all atoms move at equal velocities, and tend to move in one direction, namely, downward.<sup>13</sup> This presents the challenge

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<sup>9</sup> Epicurus infers from this that they must persist forever. Yet given what we observe of persistence and its limits (for any particular thing), we might well have grounds only for inferring that any such thing may persist a long time.

<sup>10</sup> *DL* X 41.

<sup>11</sup> *DL* X 54.

<sup>12</sup> *DL* X 61.

<sup>13</sup> *DL* X 61–62.

of explaining how atoms collide, move to the side, or move upward, if their inherent motion gives them such a downward tendency. From Lucretius and a number of commentators we learn that atomic motion in the Epicurean model incorporates a *clinamen* (swerve)—an aberration from the otherwise typical downward fall at a uniform rate.<sup>14</sup> These commentators suggest the *clinamen* insures that there will be atomic collisions, and that from such collisions atoms may be deflected sideways or upwards. Yet Epicurus does not need this additional swerve to address the challenge presented by the downward path of atoms. This is because his framework meets that challenge by allowing atoms following such a path to collide; he explicitly rejects the notion that there is one absolute sense of ‘down’.<sup>15</sup> All the same, the *clinamen* satisfies a different theoretical need for Epicurus. He wants atoms to collide in *some* way that produces not only upward and sideways motion but indeterminate states of affairs, because—unlike Democritus, perhaps—he wants his atomism without determinism.

We find another elaboration of earlier views in Epicurus’s account of atomic size and indivisibility. Though he accepts the Democritean notion that it is easier to account for variety among macro-sized objects if we stipulate more differently-sized atoms, he rejects the suggestion that there are or need be infinitely many sizes, on the grounds that there are limits on what sizes atoms can be. On one hand, no macro-sized atoms have ever been perceived, and this suggests a limit on how large they can be.<sup>16</sup> On the other hand, there should also be a minimum size for atoms, beyond which point matter cannot be physically divided—or at least never is. In this vein he argues that must be a minimal size beyond which *any* finite body cannot be divided because no such bodies can be divided infinitely. If they could be, then they would include infinitely many extended parts yet have finite extension. Hence infinite divisibility is impossible.<sup>17</sup>

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<sup>14</sup> Lucretius *RN* II 216–93. Epicurus himself does not mention the *clinamen*; one early source attributing it directly to his atomism is Cicero (for example, in *De Fato* 18).

<sup>15</sup> *DL* X 60.

<sup>16</sup> *DL* X 55–56. The problem with this argument is Epicurus’ elision from ‘there cannot be infinitely many sizes’ to ‘there cannot be every size’. There very well could be infinitely many sizes within a prescribed range.

<sup>17</sup> *DL* X 56–59; cf. Lucretius, *RN* I 599–634.



One further argument Epicurus offers in this context appears to be an attempt to establish the indivisibility of atoms while recognizing Aristotelian concerns—not with atoms *per se*—but with physical *minima*, bodies relative to which no others are smaller. Thus Epicurus suggests that minimal physical bodies cannot be divided though they may have parts, on the basis of an analogy he draws with minimal *perceivable* bodies, the breadth of which we cannot detect though it must be there all the same.<sup>18</sup> Minimal perceivable bodies have no detectable breadth: one cannot distinguish their parts by the senses. Yet they must have *some* breadth, since we can measure magnitudes by augmenting or diminishing their numbers, so that  $x$  minimal perceptibles in a row constitutes a measurable span (namely, of  $x$  minimal perceptibles's length). The same holds true of the atom, or physical minimal: "It is obvious that it is only in its smallness that it differs from what is observed in the case of perception, but does stand in the same relation".<sup>19</sup> In brief, physical minima do not have physically distinguishable parts though they must have magnitude (and so parts) if we are to say that atomic aggregates have magnitude. This sort of analogy is unworkable, though, for we cannot establish the indivisible character of one kind of minima by the indivisible character of the other, given that one sort of divisibility is physical and the other perceptual. Worse still, we should hope to be able to divide perceivable minima so long as we assume that physical minima (or anything else) are smaller—such that if the analogy really held consistently, we might expect to be able to divide physical minima, too.<sup>20</sup> The merits of this analogical strategy notwithstanding, Epicurus tries to offer an argument for atomic indivisibility from experience.<sup>21</sup> It is not a particularly successful attempt yet this

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<sup>18</sup> The term Epicurus uses is 'traversability', which seems to be most usefully understood in his writings as a thing's having breadth.

<sup>19</sup> *DL* X 58–59.

<sup>20</sup> Furley arrives at the same point by noting that reliance on this analogy may cut both ways: we might think we can take apart whatever has parts on the micro-level just as we can on the macro-level. Although Epicurus accepts that atoms have parts—simply because they are extended—he of course insists that they cannot be taken apart. Q.v. Furley (1966/1989).

<sup>21</sup> What makes this an argument from experience, Furley suggests (*Ibid.*), is that Epicurus thinks he is inferring the features of subperceptible minima from those of perceptible minima. The pressing question for the empiricist is whether to count inference from the perceivable to the nonperceivable as viable argument from experience; as we see below, Gassendi is willing to admit such arguments on empiricist grounds.

does not stop numerous subsequent commentators (Gassendi among them) from trying to salvage a viable argument for indivisibility from pieces of Epicurus's account.

Finally, what is additionally distinctive here is the range of applications Epicurus seeks for atomism. He picks up the atomist and materialist thread running through the cosmology, psychology, and biology of Leucippus and Democritus, and provides a systematic atomist picture of natural and social phenomena, including the moral life.<sup>22</sup> Epicurus draws a number of connections between his hedonist ethics and his physics. For example, that we should lead lives which enrich our happiness and friendships is a direct moral lesson of the material character of the soul, which entails our mortality as individuals: consolation lies in the present life.<sup>23</sup> Such a robust set of explanations for a broad spectrum of natural and social phenomena gives a rich texture to ancient atomism—which generations of medieval and early Renaissance scholars and theologians come to find quite repellant. This explanatory richness eventually attracts late Renaissance students of the ancient world, though, as well as Gassendi (excepting the material soul), as a promising and systematic alternative to the reigning Aristotelian world-picture.

The last of the major orthodox ancient atomists<sup>24</sup> is the poet Lucretius, who largely echoes Epicurus's views in his *De Rerum Natura*. His primary innovation is to introduce the clinamen on the grounds

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<sup>22</sup> This cursory review of Epicurean atomism is incomplete without mention of the accompanying cosmology that, by the way, Gassendi rejects nearly in its entirety. To begin with, there are infinitely many universes, and uncountably many gods that sit between the universes. They cannot be the creators for Gassendi because they themselves are composed of atoms (and because the universes are around forever, 'in both directions'). The infinitely great amount of stuff, time, and space has the consequence, according to Epicurus, that all possible physical combinations—for example, atomic aggregates—are actualized at one point or another. As de Lacy has noted, this in turn has the still more curious apparent metaphysical consequence that, while the nature of experience limits our sense of the possible, what is truly possible is limited only by the incredibly expansive (infinitely so!) actual; q.v. Philip de Lacy, "Epicurus", in Edwards (1967), volume 3, 3–5.

<sup>23</sup> Subsequent commentators easily separate such views; Gassendi makes some attempt to restore the links, though within constraints of a Christian ethics; q.v. Sarasohn (1996).

<sup>24</sup> One other significant corpuscularian of the ancient world is Hero of Alexandria, who suggests in his *Pneumatica* that the world is composed of micro-sized, non-atomic particles and interparticulate void. Gassendi borrows in part from Hero's views on the void, though not on his particular brand of corpuscularianism; q.v. *O I* 192a, 198a.

that nothing else explains collisions or the indeterminacy of motion he supposes necessary to accounting for free will. One of his arguments in this matter deserves particular attention. In Democritean atomism, it is the heavier atoms falling straight down on the lighter ones that cause collisions (the system being determinate in any event). Yet Democritus claims atoms travel through the void, where there is no reason to assume the heavier ones will fall any faster than the lighter ones. So some other cause of motion is needed to explain such collisions, and Lucretius stipulates the *clinamen* as an alternative. This is, by itself, not a reason to accept the *clinamen* as a *specific* alternative. The argument is noteworthy anyway, though, because Lucretius postulates something that looks like weightlessness in the void. It would be anachronistic to make much of this, but it is interesting that Gassendi, as we will see, also seeks to insure that atoms have within them a ready source of motion—though without the *clinamen* and on a completely distinctive basis.

In response to the atomism of his day, Aristotle suggests we have a satisfactory account of change, stasis, and the qualities of material objects if we describe their constituent primary matter and substantial form.<sup>25</sup> The difference between Aristotle and his atomist opponents is not primarily over the reasoned or empirical merits of talk about smallest particles but over the conceptual role that such particles should play in physical theory. Thus Aristotle agrees with the atomists that, by the lights of experience (in particular, as shown by chemical reactions), material objects can be categorized by their constituent elements and that, by the lights of reason, there must be limits to the divisibility of particles (at least relative to particles of living things).<sup>26</sup> However, he rejects their chief tenet, that the smallest particles are also the elemental building blocks of material objects. Rather, he proposes, the elements are the simple stuffs of air, water, fire, and earth, which combine to yield the different material substances with their particular qualities. The smallest particles, then,

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<sup>25</sup> Generally speaking the atomism of the day would have been that of Democritus and Leucippus, but Aristotle may also have been replying to Plato, who recounts a myth (in the *Timaeus*; q.v. 53c–57e) about the micro-physical structure of material objects. According to this myth, the elements of fire, air, water, and earth are composed of one of four basic types of (divisible) particles the arrangements and interactions of which help explain the qualities of those elements and the behavior of bodies they form (58a–64a).

<sup>26</sup> *Physics* I 4 (187b 28–34).

are no more than the physical minima corresponding to particular sorts of material substances they compose—that is, the component pieces of a given substance’s structure.<sup>27</sup> And so, unlike Democritean atoms, these minima are not ontologically or conceptually basic to the physical theory, given the hylomorphist story that says how they came to be the particular kinds of (minimal) bodies they are. Hence such minima cannot be significant in determining the nature of the substances they compose, because they themselves are subject to change just in case either their own matter or form changes. Despite his concessions to the atomists, then, Aristotle never allows that there is a distinctive class of smallest particles that share common features outside of being minima *per se*.

These Aristotelian views form the core of medieval discussions of manifest properties of material objects and, with minor alterations, they also provide the backbone of the ‘Peripatetic’ iatrochemistry heralded by van Helmont and Paracelsus. What unites authors throughout these various traditions are the views that an object has one or another manifest property *because* it has received the form or forms of one or more of the three or four principle elements in the right combination,<sup>28</sup> and that any subvisible structure material objects have is more or less irrelevant to such an explanation. One prominent response to this medieval and Peripatetic view of matter is the ‘*minima naturalia*’ or natural minima theory, which is widely debated in the middle ages and in sixteenth century iatrochemistry makes a prominent appearance in the writings of Julius Caesar Scaliger (1484–1558).<sup>29</sup> Scaliger embraces the ancient atomist view, suggest-

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<sup>27</sup> *Physics* VI. Nothing Aristotle says in the *Physics* rules out that a structure or its properties change when its initial particles are displaced, replaced, or added to, so nothing in his view rules out a mechanical account of change, persistence, or the nature of properties. He does not find such accounts elucidating, though, because he takes the substantial form and primary matter of substances to be explanatorily paramount and any other aspects of change, persistence, or the nature of properties to be derivative. While Aristotle and his followers might not have been captivated by a mechanical picture of matter, they (or at least Aristotle) did not deny it either, and from his own times onward there are many scientists who are acutely aware of the mechanical nature of many properties, including for example sound. This suggests that holding a mechanist view of material change and stasis does not require an atomist picture—and that the reverse should hold true as well.

<sup>28</sup> The Paracelsans replaced Aristotle’s set of four elements with the *tria prima* of what they referred to as mercury, salt, and sulphur.

<sup>29</sup> *Minima naturalia* theory was developed by, among others, Avicenna (ibn Sina), Averroës (ibn Rushd), as well as such Latin authors as Guillaume de Conches; q.v.

ing that the subvisible structure of material objects is relevant to explaining their manifest properties, because not only are there smallest particles (to which Aristotelians agree) but they are elementary in some respect. Moreover—and here he departs from the atomists—these natural *minima* share most or all kinds of features larger objects may have. These minima are at the limits of physical divisibility, like the atoms of the ancient models, yet they are thought to have some inherent fixed qualities that atoms do not feature, like coarseness or fineness. The principle difference with the atomists, though, is that Scaliger and other minima theorists of his time accept the Aristotelian picture of chemical composition as the interaction of the four elements, all the while suggesting whatever compounds we form result in part from the commingling of minima. So even as Scaliger and other minima theorists edge away from the notion that substantial form alone determines the character of substances, they continue to appeal to form and the basic elements (either Aristotelian or Paracelsan versions)—as well as the configuration and disposition of minima—to explain the generation, corruption, and standard qualities of individual substances. Thus, one debate among the minima theorists centered on the issue of whether, in chemical composition, when the minima of reagents commingle, the forms of the reagents subsist or a new, higher-order unified form emerges.<sup>30</sup> The mark of natural minima theory, then, is its reaffirmation of an Aristotelian formal account of physical and chemical properties—which seems terribly wrong to later corpuscularians of the early modern era like Boyle who insist that an adequate account of such properties may appeal only to the basic structural elements that define matter and in turn are defined materially.

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Ruth Glassner, “Ibn Rushd’s Theory of Minima Naturalia”, *Arabic Sciences and Philosophy* 11 (2001), 9–26. Later proponents included Nifo and Zabarella, along with Scaliger. In iatrochemical and alchemist discussions of *minima naturalia*, substantial forms of agents were generally held to persist throughout reactions—though subordinated to the new form that appeared, corresponding to the product. Further, the forms of those individual agents were thought to reappear upon dissolution of the product.

<sup>30</sup> For an early discussion of late Renaissance and early modern *minima naturalia* theories, q.v. Andrew G. van Melsen, *From Atomos to Atom: The History of the Concept Atom*, trans. Henry J. Koren (Pittsburgh: Duquesne University Press, 1952). More thorough treatments appear in Anneliese Maier, *On the Threshold of Exact Science*, ed. and trans. Steven D. Sargent (Philadelphia: University of Pennsylvania Press, 1982), Andrew Pyle (1995), and John Murdoch, “The Medieval and Renaissance Tradition of Minima Naturalia”, in Lüthy, Murdoch, and Newman (2001), 91–131.

At the beginning of the seventeenth century, though, a new generation of iatrochemists further pursued the natural minima programme—now with growing hints of atomism. In the eclectic theory of Daniel Sennert (1572–1637), for example, minima are conceptually merged with Democritean atoms, which he understands to have chemical properties. As Emily Michael has suggested, Sennert’s perspective gives the lie to the notion that atomism and hylomorphism are doctrines that never meet in a single author.<sup>31</sup> David Van Goorle’s *Exercitationes Philosophicae* (Leiden: J. Comelini, 1620) promotes an atomism which, like Sennert’s, borrows from the Paracelsan themes spelled out by Scaliger: we can explain chemical changes like condensation or rarefaction by appealing to the behavior of atomic parts of a given substance, but the range of changes which can take place are just those allowed by the nature of the basic elements from which a substance is composed. And one work in the Scaligerian vein is Sebastian Basso’s *Philosophia Naturalis adversus Aristotelem* (Geneva: P. de La Rovière, 1621), where we find an early molecular picture of material structure: elementary particles come together to form secondary aggregates and these in turn come together to form tertiary aggregates, the higher-order compounds having generally greater stability than the lower-order ones. Yet this programme ran its course in short order—no one could produce, of course, compelling empirical evidence on behalf of those formal, qualitative elements of minima theory<sup>32</sup>—and, with renewed interest in ancient atomist writings, early modern corpuscularians for the most part dropped their Aristotelian trappings in favor of views closer to those of the ancient atomists.

The proliferation of new atomist views did not, however, guarantee acceptability. In a well-known incident of 1624, Jean Bitaud,

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<sup>31</sup> Q.v. Emily Michael, “Daniel Sennert on Matter and Form: At the Juncture of the Old and the New”, *Early Science and Medicine* 2 (1997), 272–299.

<sup>32</sup> What kind of empirical evidence could have been hoped for, by contrast, relative to *quantitative* elements of atomism? Several authors suggest atomism supplants natural minima theory in the seventeenth century because the former lends itself more easily to quantified description than does the latter; q.v. van Melsen (1952), E.J. Dijksterhuis, *The Mechanization of the World Picture*, trans. C. Dikshoorn (Oxford: Clarendon Press, 1961), and Pancheri (1972). It is not clear, though, that such actually was a motivation for early modern atomists. At all events, this does not mean that empirical evidence was any more forthcoming in this regard than it was for the natural minima theorists (in regard to the qualities of minima). Meinel (1988) recounts the disappointing efforts of numerous atomists, and in this light the empirical evidence Gassendi offers for his brand of atomism is all the more plausible precisely because he is not as interested in a quantitative account as he is in a qualitative account; I discuss these views in chapter thirteen.

Antoine de Villon, and Étienne de Clave attempted to publicly argue the atomist case against Aristotelian hylomorphism by drawing on experimental evidence, before a Parisian public audience. Their demonstration was halted by the authorities on theological grounds and the demonstrators arrested.<sup>33</sup> Ten years later, Descartes suppressed the publication of his *Le Monde*—not because of the corpuscularian views he expresses there, though neither would those views have commended the work as doctrinally passable in the eyes of many Church authorities.<sup>34</sup> Against this backdrop of intolerance and devotion to Aristotelianism during the first half of the seventeenth century, only a handful of less-well known corpuscularian works appear in print<sup>35</sup> and some significant authors express their corpuscularian views cautiously, within the trappings of a quasi-Scholastic metaphysics (as in Descartes' recast notions of substance and form), or privately altogether (as in Beeckman's journals).<sup>36</sup> Gassendi exercises a certain boldness, then, when he proposes atomism as that 'most likely hypothesis'.<sup>37</sup> Yet, as we see in the following chapter, he was by no means alone in proposing some form of corpuscularianism. What marks his views as distinctive among the mechanical philosophers, is rather the accompanying proposal as to how his empiricist method may vindicate his atomist hypothesis.

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<sup>33</sup> Q.v. Didier Kahn, "Entre Atomisme, Alchimie et Théologie: la Réception des Thèses d'Antoine de Villon et Étienne de Clave contre Aristote, Paracelse et les 'Cabalistes'", *Annals of Science* 58 (2001), 241–286. De Clave develops a corpuscularian account of the elements, featuring arguments against Aristotelian accounts of the Peripatetics and Coimbrans, in his *Nouvelle Lumière Philosophique* (1641).

<sup>34</sup> Descartes' writings were, in the end, placed on the Index, anyway—though for attempting to account for the Eucharist in mechanical terms, and not for his corpuscularianism *per se*; q.v. Roger Ariew, "Damned If You Do: Cartesians and Censorship, 1663–1706", *Perspectives on Science* 2 (1994), 255–74.

<sup>35</sup> Other corpuscularians of the early seventeenth century include: Nicholas Hill, whose *Philosophia Epicurea, Democritiana, Theophrastica proposita simpliciter, non edocta* (Paris: R. Thierry, 1601) anticipates Gassendi's project of reviving an Epicurean systematic philosophy; Claude Bérigard, who recycles antique atomist arguments against Aristotelian physics in his *Circulus Pisanus* (Udine: Nicola Schiratti, 1643); J.C. Magnenus, who also revisits Democritean atomism in his *Democritus reviviscens sive de atomis* (Pavia: J.A. Magrium, 1646); and Joachim Jungius, who (like Sennert) presents the transformation of metals in solutions as evidence of the discrete, particulate character of matter in his *Disputationum de principiis corporum naturalium* (1642).

<sup>36</sup> On Descartes, q.v. Dennis Des Chene, *Physiologia: Natural Philosophy in Late Aristotelian and Cartesian Thought* (Ithaca and London: Cornell University Press, 1996), Roger Ariew, *Descartes and the Last Scholastics* (Ithaca and London: Cornell University Press, 1999); on Beeckman, q.v. Benedino Gemelli, *Isaac Beeckman: Atomista e Lettore Critico di Lucrezio* (Florence: Leo S. Olschki, 2002).

<sup>37</sup> O I 335b.





## CHAPTER EIGHT

### THE MECHANICAL PHILOSOPHY

Robert Boyle grouped his seventeenth century corpuscularian predecessors and contemporaries as the ‘mechanical philosophers’.<sup>1</sup> He intended the term as neutral between atomists and non-atomist defenders of a common vision—that the physical world is machine-like and composed of a discernable material substratum the bits of which, in combination, give rise to familiar macro-sized entities and phenomena. While their differences regarding the nature of matter were great, two issues drew together early modern corpuscularians of all sorts, Gassendi among them. First, they were concerned to provide a suitable ontology for the mechanical philosophy. Among other things, this entailed making the mechanist picture work all the way down to the subvisible level, and building that picture up from that level. One reason this is necessary is to guarantee the scalar invariance of physical laws—that such laws work across the spectrum of magnitudes. Second, they were for the most part concerned to meet empiricist constraints and interests of the new science. This entailed,

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<sup>1</sup> Robert Boyle, *The Excellency and Grounds of the Corpuscular or Mechanical Philosophy* (1674); q.v. Peter Anstey, *The Philosophy of Robert Boyle* (London; New York: Routledge, 2000) and Antonio Clericuzio, *Elements, Principles and Corpuscles: A Study of Atomism and Chemistry in the Seventeenth Century* (Dordrecht: Kluwer, 2000). This term has had lasting historiographical currency (even if Boyle was not intending a historical account), thanks to Boas’ (1952) influential study; q.v. Marie Boas [Hall], “The Establishment of the Mechanical Philosophy”, *Osiris* 10 (1952), 412–541. More recent studies include Alan Gabbey, “The Mechanical Philosophy and its Problems: Mechanical Explanations, Impenetrability, and Perpetual Motion”, in *Change and Progress in Modern Science*, ed. Joseph C. Pitt (Dordrecht: D. Reidel, 1985); Martin Tamny, “Atomism and the Mechanical Philosophy”, in *Companion to the History of Modern Science*, ed. R.C. Olby, G.N. Cantor, J.R.R. Christie and M.J.S. Hodge (London; New York: Routledge, 1990); and Daniel Garber, “Descartes, Mechanics, and the Mechanical Philosophy”, *Midwest Studies in Philosophy* 26 (2002), 185–204.

A canonical list of mechanical philosophers would likely include Descartes, Gassendi, and Boyle himself, as well as Isaac Beekman, Nicholas Lemery, Christiaan Huygens, and Newton (the last viewed by some as a transitional figure, though his commitments to corpuscularian explanation are clear). Other figures, including Galileo (only a quasi-corpuscularian) and Hobbes, are more contentiously counted among the mechanical philosophers.

among other things, saying what empirical evidence might be adduced for corpuscularian claims.

As regards the first issue, let us begin by assessing what is meant by ‘mechanism’ or the ‘mechanical philosophy’—and how atomism as an ontological thesis might relate to it. Early modern philosophers and scientists who espoused the mechanical philosophy promoted a group of theses—some scientific claims *per se* and some claims about the way science should be pursued—but all based on the view that material objects behave in the ways of artificial machines such as clocks (to take a popular seventeenth century image). In principle, their behavior is regular, measurable, repeatable, predictable, and produced by the behavior of their component parts.

As Martin Tamny (1990) has noted, the mechanical philosophy had at least these two facets: a mechanist methodology, according to which our best physical hypotheses tell us about ‘real properties’ of bodies underlying manifest phenomena—and which suggests that such hypotheses are supported by our best evidence, empirical or otherwise; and a corpuscularian ontology, according to which all macro-sized objects consist of micro-sized parts bearing those real properties. What ties the two theses together is the suggestion that, given the corpuscularian ontology, our best physical hypotheses will locate the quantifiable, real properties of bodies in corpuscles and so allow us to reinterpret the behavior of all macro-physical objects in terms of the actions, interactions,<sup>2</sup> and states of their constituent corpuscles.<sup>3</sup>

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<sup>2</sup> That corpuscular interaction plays such a central role in this view, and a number of mechanical philosophers are committed to a ‘no action at a distance’ thesis, might seem to suggest that a corpuscular ontology is just what mechanists need to establish the latter point. Indeed, one interpretative tradition has it that the notion of action-at-a-distance confuses body and mind—that any such action represents an ‘animistic physics’ (Mary Hesse, “Gilbert and the Historians”, *British Journal for the Philosophy of Science* 11 (1960), 1–10; 130–142) which was eliminated over time in favor of a purely material means of action. However, there are independent historical reasons for favoring the ‘no action at a distance’ thesis, among them a long tradition of rejecting the void, and commitment to the species theory of image transmission; q.v. Pyle (1995), 359–369, 616–617. Moreover, a corpuscular ontology alone does not proscribe action at a distance. Some mechanical philosophers—Gassendi, Boyle, and Newton among them—invested spirit-like features in matter, all the while maintaining that such features could arise (and be conceptually sustainable) without appeal to spiritual substance *per se*; q.v. chapters 9 and 10. Among the historical precedents for such a view, we find the Stoic *pneuma* tradition. For the connection to Newton, q.v. Betty Jo Teeter Dobbs, “Stoic and Epicurean Doctrines in Newton’s System of the World”, in *Atoms, Pneuma, and Tranquility: Epicurean and Stoic Themes in European Thought*, ed. Margaret J. Osler (Cambridge: Cambridge University Press, 1991), 221–238.

<sup>3</sup> This interpretation has it that there are methodological and ontological theses

This promise of mechanically explaining all physical phenomena by reference to the real and quantifiable qualities of matter might look somewhat reasonable in Descartes's hands, more so in Newton's, and somewhat less so in Gassendi's, as a function of their facility with mathematics and measurement.<sup>4</sup> But the resulting outline for explaining physical phenomena is roughly similar for the various mechanical philosophers. Such explanations consist in giving (what are in the optimal case precise) descriptions of the sets and relations of basic properties of the elemental units of matter, and showing how these descriptions can be derived from, or are at least consistent with, our basic physical (and metaphysical) commitments—whether derived from experience, reason, or both.

Looking beyond method and ontology, there is at least one other thesis the mechanical philosophers generally share—a commitment to identifying principles that govern the motion of matter—and thus the behavior of bodies, and to the view that these principles lend a regular, law-like character to the explanations they suppose their methodology to generate.<sup>5</sup> More specifically, most if not all of the central figures among the mechanical philosophers specify that some foundational principles of kinematics or dynamics (including principles

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in most if not all instantiations of the mechanical philosophy, and the two theses are not identical. It is, naturally, a further step to suggest that the two theses are or were ever considered to be independent. Tamny's point is that the central thesis of the mechanical philosophy is the methodological one, whereas the ontological one is (just) an important ancillary. They might be inseparable in the minds of the mechanical philosophers themselves for various reasons but it does not follow that they are one and the same thesis or even that they cannot logically be separated.

<sup>4</sup> This is not to suggest that these or any other mechanical philosophers offered any concrete notion as to how to conceive of corpuscles in true quantified terms. The suggestion is rather that the idea of quantified description of the world facilitates an ontological picture which stipulates that matter's smallest bits in principle are most fruitfully thus described.

<sup>5</sup> We can also generally identify in the mechanical philosophers an *epistemological* thesis—at a slightly broader gauge than the methodological thesis that Tamny identifies—that can be roughly characterized as: whatever qualities we know about through sensation are explainable in terms of the few basic properties of bodies.

In other words, to account for any knowledge of sensible qualities—and not just our rigorous, scientific understanding of them—we need (among other things) to identify the fundamental physical properties and our means of interaction with them. This thesis, too, strongly suggests a corpuscularian ontology, but it does not follow from this strong suggestion that the ontology alone is either identical to or indistinguishable from the larger mechanist programme, which includes as well the methodological and epistemological theses—and a commitment to a principled account of the motion of matter.

of inertia, conservation of motion or momentum, and eventually, a mature force concept) govern the motion of matter and so the behavior of all bodies.<sup>6</sup> Such principles are crucial to the mechanical philosophy<sup>7</sup> because they are required in order to effect the methodological thesis which, we have seen, promotes the explanation of phenomena like physical change and the sensation of manifest properties by reference to real properties. Thus precise characterizations of matter in motion allows accurate specification of the physical states of whatever bears such real properties, and regular (or minimally, regularizable) characterizations of matter in motion fulfill the promise of the machine metaphor—that mechanistic accounts have predictive power and the phenomena are repeatable (at least in principle) because the physical behavior as characterized is law- or principle-abiding.<sup>8</sup>

What relevance did such laws of motion under development have for the mechanical philosophers' conceptions of a matter theory that yields micro-physical accounts of macro-physical phenomena? It is reasonable (at least given the hindsight of classical mechanics) on grounds of parsimony to have the same laws of motion govern both

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<sup>6</sup> The mechanical philosophers did not necessarily view such principles as sufficient for accounting for the behavior of bodies. Indeed, it is not even clear that they always thought such principles could fully account for the motion-phenomena in question. Thus, for example, the phenomenon of inertial motion for Newton was in some way related to the *vis insita* he held to be a real and inseparable property of bodies—in addition (and, some would say, in direct contradistinction) to its relation to the inertial principle he proposes as governing the motion of bodies. Thanks to Martin Tamny for this point.

<sup>7</sup> Naturally, the mechanical philosophy is not unique in this regard. Earlier attempts at fundamental principles of motion include, of course, Aristotle's noninertial views, but also the impetus theories promoted by Jean Buridan and Nicholas of Oresme. As I.B. Cohen (*The Birth of a New Physics*, New York: W.W. Norton & Company, Revised & updated edition, 1991) suggests, however, these are more aptly viewed as belonging to kinematics than to dynamics *per se* because there is no concept, or even suggestion, of 'force' or 'mass' in these earlier physical accounts. In any case, the novelty in this context is the role such principles of motion play in the mechanical philosophy. Those concepts undergo a rich and complex development over the course of the seventeenth century, culminating in Newton's *Principia*, setting constraints on the behavior of bodies that yield the regularity we expect from the mechanist picture. Westfall and Gabbey recount this transitional development; q.v. Richard S. Westfall, *Force in Newton's Physics: the Science of Dynamics in the Seventeenth Century*, London, Macdonald and Co.; New York: American Elsevier, 1971; and Alan Gabbey, "Force and Inertia in Seventeenth-Century Dynamics", in *Studies in History and Philosophy of Science* 2 (1971), 1–68.

<sup>8</sup> Thanks to Lisa Downing for discussing these points.

micro-sized and macro-sized bits of matter. For if these laws varied depending upon the size of the matter in motion, we would need *extra* rules to say when a given bit of matter was governed by which laws, and we would have the likely complex task of saying how this was possible to begin with. As it happens, whether or not the mechanical philosophers sought to avoid this sort of task, they generally adopted or assumed a meta-principle of the *scalar invariance* of their physical laws. Consequently, whatever physical laws govern macro-sized phenomena would also govern micro-sized phenomena, and vice-versa, so that the fundamental principles of motion should apply equally to atoms, mid-sized objects like tables and chairs, and objects of great scale like the planets.<sup>9</sup>

For example, Descartes must hold such a meta-principle to insure that his laws of motion range over all extended substance, such that his corpuscles and planets move in the same sorts of ways (generally speaking), and the kinds of mechanical explanations we generate for either will closely resemble one another relative to those laws. Indeed, Descartes's continuum of matter requires that his laws of motion apply independent of scale.<sup>10</sup> Other mechanical philosophers, too, had good cause for maintaining a scalar invariant physics. Gassendi, for his part, held such a view for reasons both on atomist and general physical grounds.<sup>11</sup> One example of such physical

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<sup>9</sup> Newton explicitly proposed such a meta-principle of 'transduction', as J.E. McGuire has indicated; q.v. "Atoms and the 'Analogy of Nature': Newton's Third Rule of Philosophizing", in *Studies in the History and Philosophy of Science* 1 (1970), 3–58. If my characterization of Gassendi's view is correct, the history of that meta-principle can be pushed back further, at least in germinal form.

<sup>10</sup> Q.v. Pyle (1996), 532; and J.E. McGuire (1970), 18. If scale did matter to Descartes' laws of motion, then we would need to employ distinctive laws for the same bits of matter, depending on whether they were part of larger or smaller bodies. To the contrary, Descartes precludes that last possibility when he proposes the conservation of motion in matter, as holding across all bodies, irrespective of size: "... although motion is only a mode of matter which is moved, matter nonetheless has a certain quantity of motion that never grows or diminishes, even where there would be sometimes more and sometimes less of it in some of its parts [in the Latin (*AT* VIII-1 61): "... [motion] has a certain determinate quantity; and this, we easily understand, may be constant in the universe as a whole while varying in any given part."]; that is why, when a part of matter is moved two times faster than another, and that other is two times larger than the first, we must think that there is as much motion in the smaller as in the larger, and that always and when the motion of one part diminishes, that of some other part grows proportionately." (*AT* IX-2 83–84; *PP* Part II § 36; *CSM* I, 240). Thanks to Dennis Des Chene for discussing this point.

<sup>11</sup> Martin Tamny has suggested another sort of motivation for the mechanical

grounds is Gassendi's clear interest in a science of motion that treats micro- and macro-sized bodies equitably. Thus, he takes his concept of weight in the case of atoms to correct the general Aristotelian view about the fall of bodies—that the natural tendency of bodies is to fall downwards, towards a worldly center:

By weight . . . we must not understand an inclination of atoms toward the center of the universe . . . but a 'force' or natural impulse [that moves atoms] from one part of the universe to another without end.<sup>12</sup>

That there is no center of the universe towards which bodies fall is also the crux of his argument for a principle of inertia in *De Motu*. Of course, Gassendi might have construed the Aristotelians as being wrong in the context of the passage above on wholly distinct grounds. It is unreasonable to suppose, though, that he takes his proposal concerning the fall of atoms to correct the Aristotelian view of falling macro-sized bodies—unless he also thinks the falls of such bodies and their corpuscular components share the same dynamic characteristics (even if, somehow, they do not share the same causal principles).

In chapter ten, I explore in detail such issues concerning the mechanical philosophy as result from Gassendi's views of atomic motion. Here I sketch expectations of the mechanical philosophers for the atomist hypothesis. Among its supporters, that hypothesis represents not only as a prominent variant of mechanist ontology but also a thesis with significant implications for the aforementioned perspectives on empirical knowledge, scientific method, and the nature of motion and forces. Some of atomism's consequences for epistemological and methodological theses of the mechanical philosophy are surveyed in chapters thirteen and fourteen; in the next few

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philosophers to have adopted a meta-principle of scalar invariance: by doing so they provide warrant for those claims about physical phenomena on one scale which they infer from claims about such phenomena on any other scale. Scalar invariance is beneficial, then, because it allows these scientists and philosophers to generate the sorts of results they are hoping the mechanical philosophy will yield. This motivation is consistent with Gassendi's notion that elements of scientific method are driven by utility considerations (q.v. chapter seven). Incidentally, alternative theses which suggest that macro-level events are radically distinct from micro-level events do not bear the same explanatory yield (for example, where the former are emergent phenomena relative to the latter) or else rely on notions unavailable to the early moderns (for example, where the former are statistical outcomes of the latter).

<sup>12</sup> MS Tours 709 folio 85r; q.v. Brundell (1987), 119–120.

chapters I focus on issues concerning the motion of bodies—what might account for variability in their motion, whether and how motion might be conserved, and whether atomic motion could be construed as inertial along with supra-atomic motion. Gassendi's atomism does not sit perfectly with these mechanist claims regarding these issues—an indication that he has failed to equip his broader physics with an atomist ontology. Naturally, he would have been further remiss for not having tried, and these two ends of his physics at least feature some suggestive points. His atomism suggests, for one, how physical phenomena on all scales results from the properties, relations, and states of micro-sized bits of matter. His proto-dynamics suggests, for another, that the motion of matter obeys cardinal principles which anticipate, at least crudely, two of Newton's laws of motion. One intriguing aspect of this whole picture is that Gassendi appears to have attempted to surpass a purely kinematic account. He conceives of the motion of larger bodies as the consequence of their 'motive force'—a composite of their constituent atoms' motion, which in turn he takes to result from their inherent weight. Given the difficulties in integrating his macro-physics and micro-physics, however, it is hard to see how he could have developed this conception as a successful dynamics.

An altogether different difficulty for Gassendi is whether his atomist hypothesis meets his own empiricist constraints. One way of putting this issue is to ask what empirical evidence for atomism would look like given that atoms are supposed to be below the threshold of perception. This particular way of putting things is historically intriguing in that the differing ontologies of various mechanical philosophers were largely not distinguished in their own times. Dijksterhuis speculates that this is precisely because neither the theoretical entities they proposed nor the behavior of those entities were distinct on the observable level.<sup>13</sup> Whatever the failings of seventeenth century chemists and savants, the distinctions between atomism and other corpuscularian or non-corpuscularian matter theories are clear enough, and in chapter nine we see what these amount to, in Gassendi's view.

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<sup>13</sup> Dijksterhuis (1961), 429. Thus Descartes's parts of space (whether at rest or in motion) behave just like fine particles of matter, his fine particles in turn behave like atoms or their aggregates, and his interstices of celestial matter behave like the *vacuum separatum* proposed by anti-plenists like Gassendi.

But were such distinctions supposed to be empirically rooted at all, and if so, how? A common view is that Gassendi's arguments for atomism are by and large an *a priori* affair, and that, as Lynn Sumida Joy has proposed, historical analysis and tribute significantly shape the content of Gassendi's atomist claims. However, some of his historically based arguments and other, more original arguments depend on what he construes as empirical evidence. That he makes this construal depends on his notion (visited in chapter two) that inferences based on signs of unobserved phenomena constitute empirical reasoning such that beliefs we thereby acquire or develop are the stuff of empirical knowledge.

Before looking at these issues, though, the nature of Gassendi's atomism merits a closer look. In the beginning of chapter nine, I examine the background metaphysics undergirding Gassendi's corpuscularian theory, in historical context. Next, at the end of that chapter, and start of chapter ten, I examine specific elements and contours of that matter theory, focusing on atomic motion as a source of friction with his broader mechanist claims. By contrast, his use of an atomist hypothesis in accounts of attractive powers and organic generation reflect applications of an ontological strategy that largely conforms with his general physics. These accounts—which I explore in chapter eleven—illustrate as well Gassendi's allowance for entertaining atomist explanations without first establishing empirical confirmation. His primary concern in pursuing this atomist programme is rather to lay out a picture that is empirically plausible, focusing on the most readily identifiable micro-structure underlying material objects and phenomena—the molecular aggregates of atoms. Given the limits of our empirical access to the subperceivable, Gassendi shows less interest in identifying what might in turn underlie *those* aggregate structures—or what may amount to the same question—why we should expect to find one sort of structure and not another.



## CHAPTER NINE

### ULTIMATE PARTICLES AND ESSENTIAL FEATURES

The first signs of Gassendi's atomist sympathies appear in his earliest works and correspondence, in which he rejects much of the style and some of the substance of philosophy in the late Aristotelian tradition.<sup>1</sup> Indeed, a number of commentators suggest that Gassendi does not come to his atomism because he thinks it is the most likely physical hypothesis about the underlying structure of matter—as he suggests in the *Animadversiones* and the *Syntagma*. Rather, they propose, Gassendi is a thinker in the Renaissance mold who simply dusts off this central component of Epicureanism in order to introduce a systematic philosophical alternative to the robust range of received Aristotelian views.<sup>2</sup> Though he shares most of Epicurus's claims about atoms (and many of the Epicurean arguments for those claims), Gassendi disagrees on key points, which suggests it is the merits of the view itself, and not simply a general restoration of Epicureanism, that leads him to his atomism.

Gassendi states his primary grounds for embracing atomism clearly enough: he thinks it is a good theory relative to its competitors. In particular, atomism offers explanatory power that other views about the nature of matter cannot match:

. . . this theory of matter has the advantage that it does not do a bad job of explaining how composition and resolution into the primary elemental particles is accomplished, and for what reason a thing is solid, or corporeal, how it becomes large or small, rarefied or dense, soft or hard, sharp or blunt, and so forth. . . . these questions and others like

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<sup>1</sup> Q.v. Rochot (1944).

<sup>2</sup> This is a common enough theme in the Gassendi literature (q.v. for example, Rochot (1944), Joy (1987), Osler (1994); it is the central thesis in Brundell (1987). If this is really what interested Gassendi in atomism, there would not be much point to studying his views over, say, Epicurus's. The real difficulty with this perspective, though, is that it distorts Gassendi's obsessive, learned rehabilitation of Epicurus into the sum total of his philosophical interests, instead of seeing it as the historical project he pursues at the same time as those distinct (though surely related) interests.

them are not so clearly resolved in other theories where matter is considered as both infinitely divisible and either pure potentiality . . . or endowed with a certain shape from among a very small range of possibilities, or endowed with primary and secondary qualities, which either do not suffice to explain the variety in objects or are useless. . . .<sup>3</sup>

Even though he finds atomism to be the most promising matter theory among various alternatives, Gassendi thinks there is room for improving upon the ancient doctrine. His proposed improvement is that atomism conform with something like this rule: we may adopt an hypothesis we recognize is not entirely correct, so long as we correct whatever is recognizably false about it. He writes: “. . . there is nothing to prevent us from defending the opinion which decides that the matter of the world and all the things contained in it is made up of atoms, provided that we repudiate whatever falsehood is mixed in with it.”<sup>4</sup> In other words, atomism is a tenable hypothesis only if we first eliminate the falsehoods of the classical view:

. . . in order to recommend the theory, we declare first that the idea that atoms are eternal and uncreated is to be rejected and also the idea that they are infinite in number and occur in any sort of shape; once this is done, it can be admitted that atoms are the primary form of matter, which God created finite from the beginning, which he formed into this visible world, which, finally, he ordained and permitted to undergo transformations out of which, in short, all the bodies which exist in the universe are composed.<sup>5</sup>

While this theoretical cleansing bears salutary theological results,<sup>6</sup> Gassendi’s motivation in this regard is not entirely, or even primarily, religious. What makes the cleansing a worthy project is the notion

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<sup>3</sup> *O I 280a; B 399*. Gassendi takes a swipe at Descartes’s view, by including among his list of less successful matter theories those in which matter is infinitely divisible and endowed with primary and secondary properties.

<sup>4</sup> Gassendi claims to infer such a rule from a stance taken towards Epicurus by the medieval French philosopher Guillaume de Conches (whom he refers to by the standard pseudonym ‘Aneponymus’). Curiously, his quotation from Guillaume suggests instead that (a) there are no wholly false opinions yet (b) their true parts are unsalvageable anyway: “There is no opinion so false that it does not have some truth mixed in with it, but still the truth is obscured by being mixed with the false”. *O I 279b; B 398*.

<sup>5</sup> *O I 280a; B 398–399*.

<sup>6</sup> Gassendi writes: “So stated, such an opinion has no evil in it which has not been corrected just as it is necessary to correct opinions in Aristotle and others which make matter eternal and uncreated in the same way, as others also make it infinite.” *O I 280a; B 399*.

that the theory is not wholly false, and instead bears some resemblance to the truth about the nature of matter. Only after electing to fashion a ‘truer’ atomism—where such resemblance to the truth is measured in empirical terms—does Gassendi land on Church doctrine as one important constraint guiding his emendation of ancient atomism. It is not the only such constraint, though.

In what follows, I explore the central theme of Gassendi’s atomism—his background metaphysics, views on the finite divisibility of matter, and claims regarding the qualities of atoms and their aggregates. Following the Epicurean (or more generally, ancient atomist) model, Gassendi starts with a basic ontology of matter and void, and develops a thoroughgoing account of the physical world rooted in a picture of the inherent features of atoms. The general range of phenomena and entities for which Gassendi offers atomist accounts owes much to the ancients. Many of the particular explananda do not, though, and as we see below, a significant number of Gassendi’s explanatory arguments are his own, at least in part.

### 1. *Metaphysics*

In the first chapters of the *Physics*, Gassendi introduces notions of absolute space and time according to which the universe is that which contains material Creation. In the colloquial language of metaphysics, he lays out the ‘floor plan’ of his picture of the universe in which he understands God to place the ‘furniture’, namely, atoms and their amalgams. Space, time, accident, and substance are the basic and real (non-ideal) categories of existence: space and time are not modes of substance.<sup>7</sup>

‘Matter’ refers to substance that exists in space and time; indeed, it is the sole and unchanging stuff of physical things and so must exist as long as there are physical things. If it did not, we would have to explain how something can come from nothing, which Gassendi takes to be naturally (though not supernaturally) impossible.

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<sup>7</sup> O I 184a. While Gassendi does not specify a further definition of substance, his use suggests that he is following a fairly standard, broadly Aristotelian sense of that which exists, endures accidents (has properties), and is subject to change. That substance exists in space and time is insufficient to make space and time modes of substance; they exist independently of any substance.

Further, if as the Scholastics maintain, matter was simply characterless stuff, we would have to explain how individuated things can be composed of something with no features. This challenge is easily met by the Scholastics, for whom form is what individuates things in the first place.<sup>8</sup> But Gassendi wants bits of matter to have their distinctive qualities without the Scholastic imposition of form; in particular, he proposes that matter has essential and accidental qualities and that we can only know the accidental ones, through experience.

The Scholastics also distinguished between phenomenal qualities we know experientially and a set of primary or fundamental elements which are the components of mid-sized objects and which, in virtue of their qualities, give rise to the phenomenal qualities. Thus mid-sized objects are hot because a significant part of their composition is whatever element that is characteristically hot. There are various views as to how many fundamental elements there are—for example, three according to the Paracelsans, four according to the Aristotelians, and some combination of these last two sets according to van Helmont—but all these perspectives suggest there is nothing essential that all the elements share. For Gassendi, such accounts are problematic, since we cannot postulate enough primary elements to account for the variety we find in nature—the Scholastic supposition here being that only micro-level variety among the elements or their properties begets macro-level variety.<sup>9</sup> This supposition is not promising, though, for we do not need those sorts of variety on the micro-level to generate the broad spectrum of macro-level properties. What we need, at a minimum, is a broad range of possible structural combinations among the elements. This much was emerging

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<sup>8</sup> This view is recommended by Suarez, for example; q.v. *Disp* 5 §3 ¶5, *Opera* 25, 263. This is by no means a uniform view among the Scholastics, however. Thomas proposes that a specific measure of *materia quanta* (quantified matter) performs this role, and Fonseca identifies the individuating principle as those features of a thing which constitute its essence as an individual; q.v. Des Chene (1996), 367–370.

<sup>9</sup> Gassendi's discussion of cold as a phenomenal quality illustrates this point. In his view, the quality of heat is characteristic of just those atoms which tend to be associated with heat—whereas on the Scholastic view, he notes, such a quality corresponds to the element of fire. By contrast, though, there is no element on the Scholastic conception that clearly or even plausibly corresponds to cold (Scholastic debates on the matter notwithstanding). It is far simpler to suppose, Gassendi suggests, that cold arises from origins akin to those of other such qualities bearing mechanical, material explanations—per the atomist template; q.v. *O I* 399a–400b.

as a clearer view in some seventeenth century matter theorists of Aristotelian bent, such as Sennert, Basso, and Jungius. This position is enunciated most clearly by Gassendi as his proposed means of generating macro-level variety. Having dismissed the traditional Scholastic view, his alternate suggestion is that we do not need to postulate more than one basic kind of matter, and that the combinations and interactions of matter's basic units suffices to yield the full range of macro-level properties. As we see below, he maintains that we thereby may avoid the undesirable Scholastic view that qualitative variety may be shouldered by the self-same qualities we attribute to micro-level elements. Curiously, though, in his own corpuscularian accounts of macro-level qualities, he later retreats to a view that locates just such self-same qualities on the micro-level. In short, his proposal is that, for a large range of qualities  $x$ :  $x_1, \dots, x_n$ , some  $x_i$ -corpuscles are the source of an associated quality  $x_i$  in the larger bodies they compose. Those phenomenal qualities result from our experience of bodies composed of the sorts of atoms with the corresponding physical features and combinations which lend themselves to our sensations of  $x$  or  $y$  qualities—much as we experience color, on a subjectivist account.

As with matter and its elemental particles, the paramount claim Gassendi hopes to establish about the void is existential—that there is one. In fact, following Hero of Alexandria, he holds that there are *three* kinds of void: *inane separatum*, or the void of infinite expanse beyond the atmosphere (in which God produces Creation);<sup>10</sup> *inane disseminatum*,<sup>11</sup> or the interparticulate void between constituent atoms of whole bodies; and *inane coacervatum* or *grandiusculum*, or the interparticulate voids ‘cobbled’ together by experimental means (and which would otherwise not exist).<sup>12</sup> As we have seen, Gassendi takes the barometric experiments of his day, including his own at Toulon, to demonstrate the existence of at least a partial, disseminated void. In addition to offering such empirical argument, he echoes ancient atomists’ reasoning. Thus, for example, he rehearses the classical

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<sup>10</sup> O I 185a–187a.

<sup>11</sup> O I 192a–196a.

<sup>12</sup> O I 196b–203a; cf. Hero of Alexandria, *The Pneumatica of Hero Of Alexandria*, trans. Joseph Gouge Greenwood; ed. Bennet Woodcroft (London: Taylor, Walton and Maberly, 1851), Reprint edition, intro. Marie Boas Hall (London; New York: Macdonald-American Elsevier, 1971); and Grant (1981).

arguments that without a disseminated void between the parts of bodies, there is no ready way to explain how bodies may divide and separate at the level of basic particles, and that without the *inane coacervatum*, there is no ready way to explain the motion of bodies through space.<sup>13</sup>

Beyond reviving these antique views, this theory of the void also lays the groundwork for at least two more modern elements of Gassendi's physics.<sup>14</sup> For one, as a consequence of identifying *inane separatum* as the space in which Creation takes place, such vacuum must exist independent of whatever matter lies within, and is accordingly non-relative and non-ideal. The motions, actions, and changes of matter take place against a backdrop of absolute space—a view that Newton later adopts.<sup>15</sup> Of more immediate significance for his corpuscularian views, Gassendi presents the void as a feature of the universe with a well-defined structural role, though without a distinguishable structure. He supposes the void to be a non-substantial attribute of the universe, leaving matter as the only physical substance. Gassendi notes that critics of atomism think it entails that the void is a substance on the grounds that the void is a sometime component of bodies (along with matter). The worry of these crit-

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<sup>13</sup> As we have seen, Gassendi dismisses the plenist view that mutual displacement of matter also makes motion possible, even in the absence of empty space—employing the classical argument that only empty space explains the *commencement* of motion. For plenists like Descartes to explain how motion begins is particularly difficult, given the centrality of circular motion in his scheme.

<sup>14</sup> The roots of Gassendi's views on space and void have been traced to Francesco Patrizi and Bernadino Telesio; q.v. Grant (1981) and John Henry, "Francesco Patrizi da Cherso's Concept of Space and its Later Influence", *Annals of Science* 36 (1979), 549–75.

<sup>15</sup> Gassendi's notion of incorporeal space as boundless and motionless allows that no changes or motions within space can have any causal effect on it: "... when some object, or part of the universe, moves from its place, this space in which it is situated does not move along with it, but remains motionless as it is left behind, and the space across which it journeys is constantly motionless, as is the space towards which it travels and which receives it." (*O* I 183a; *B* 388). This absolute nature of Gassendi's space exceeds even that proposed by Newton, who takes God to create space and co-extensive with it *qua* absolute container (or in Clarke's phrase, space is God's 'sensorium'); q.v. Milič Čapek, *The Philosophical Impact of Contemporary Physics* (Princeton: Von Nostrand, 1961) and Samuel Clarke, *The Leibniz-Clarke Correspondence*, ed., intro., and notes H.G. Alexander (Manchester: Manchester University Press, 1956). Gassendi, for his part, reasoned that God creates the universe in absolute space, which not only precedes Creation but does not depend on God in any way, and would survive the end of the universe (*O* I 183a–184a; *B* 388–340).

ics is that making the void a substance is a violation of the tenet that *nihil ex nihilo*. Novel combinations of matter may yield new *inane disseminatum*, or altogether new void, which, this worry suggests, would be previously nonexistent substance. But such criticism is based on a misunderstanding, Gassendi contends. A viable atomism may have it that both atoms and the void are ‘principles’—by which Gassendi apparently means ‘primary element’, following a Scholastic tradition—it does not follow from this, however, that they are both substantial. Whereas atoms are primary principles of material substance, voids are non-substantial principles of separation in which bodies are located, and by which they are separated and have the sort of supra-atomic structure they have.<sup>16</sup>

## 2. *Finite Division of Matter into Elemental Parts*

To establish that atoms are the primary principles or elements of matter, Gassendi draws deeply on the well of ancient atomist argument. This sort of ‘historical evidence’ or ‘testimony’ tolerably counts as one manner of support for physical claims at the dawn of the early modern period.<sup>17</sup> Given Gassendi’s pronounced empiricism, though, the degree of his reliance on such testimony is surprising. He strikes an even more surprising anti-empiricist chord in the introductory chapter of his *Physica* (*Physicae Prooemium*) when suggesting that, in principle, our understanding of the natural world may allow a stipulative account consisting of the right physical postulates.<sup>18</sup> Such a physical account would tell us that material objects are composed of ultimate particles:

... These ultimate particles [of matter] can be called atoms or indivisibles—not that they are completely derived of parts—but in the sense that there exists no force of nature that is capable of reducing them. The atoms are solid corpuscles and they comprise little bulk. When many atoms adjoin one another, there may form a body which has a bulk, or let us say, a mass of a greater magnitude. The extreme

<sup>16</sup> O I 281a; B 403.

<sup>17</sup> Q.v. Serjeantson (1999).

<sup>18</sup> O I 130a–132b. In his phrasing, there is nothing ‘incongruous’ (*incongruum*) about such a view, by which he may mean something such as ‘contradictory’ or ‘inconsistent’—though with *what* is not clear.

tininess of an atom is located, in inconceivable proportions, on [the other] side of all sensation. . . . There are no sensible bodies, as little as they may be, that are not composed of a multitude of inconceivable atoms, etc.<sup>19</sup>

In the end, though, this approach is unacceptable for Gassendi. The problem is not that such pronouncements place his physics beyond the reach of empirical demonstration—it is that such a stipulative physics raises more questions than it answers: “. . . it would present so many things to insert for explaining the difficulties we would ordinarily meet along the way, that the [stipulated] propositions would be somewhat stifled by the number of things to say.”<sup>20</sup> Gassendi’s alternative tack is a series of reasoned defenses—frequently, amplifications and restatements of Epicurean and Lucretian arguments—of basic atomist tenets, including claims as to their existence and status as the primary material principles.

Thus, for example, assuming material objects must have *some* substratum composed of basic and indivisible elements—in Gassendi’s terms, ‘principles’—he proposes that atoms, as the *best* candidates for the role of substrata, are the material principles in question. To arrive at his first assumption, he follows Epicurus and Lucretius in adopting the Parmenidean dicta that nothing comes from nothing and (conversely) that all matter must come from something. He further embraces the ancient view that those dicta entail a common substratum for all matter given that the composition and resolution of material things always yield matter.<sup>21</sup> To establish that atoms are the best candidates for serving as this common substratum, he reasons that *whatever* would serve as matter’s substratum cannot pass from existence,<sup>22</sup> and that elements of such substratum would be incapable of passing from existence only if they were indivisible and thus had no void—that is, were solid.<sup>23</sup> Yet this common substratum cannot be featureless, formless primary matter, as the Aristotelians

<sup>19</sup> *O I* 131b.

<sup>20</sup> *O I* 132b.

<sup>21</sup> *O I* 232; *AN* 180. Cf. *DL* X 40; *RN I* 540–550.

<sup>22</sup> *O I* 232, *AN* 180.

<sup>23</sup> “Just as every divisible body should be divisible because of an intervening void and parts which dissociate and even allow the ingression of an external power to separate them, what is indivisible should be such that it is entirely full and solid or such that it has no void from which it fears a separation of parts. . . .” *AN* 180; cf. *O I* 258b. The translation is Lynn Sumida Joy’s (1987, 150).



propose. It should have *some* identifiable and unchanging features because such features are ineliminable from anything that is matter.<sup>24</sup> He concludes that all material objects must be composed of elemental particles sharing those features essential to matter—and those particles just are atoms.

The reasoning is not watertight. For one, while the material substratum might only resist corruption if its component elemental particles were indivisible, this claim presumes that the substratum is composed of discrete particles to begin with—which his anti-atomist opponents had no reason to accept. Further, though his atomist story might suffice to explain the common material products of iatrochemical analysis and synthesis, it is not necessary for that task. Even if we take such products as evidence of a material substratum (and it is not obvious from his reasoning here why we should), further argument is needed to accept that there must be only *one* kind of substratum with the same features across particles. Gassendi apparently recognizes as much, and (as we see below) in developing his account of the particular features of atoms, he identifies the properties any bit of matter, however small, must have—of metaphysical, physical, and theological necessity.

In a further line of reasoning borrowed from Lucretius, Gassendi attempts to establish atoms as the primary principles of matter on the grounds that some fundamental material elements must be impenetrable if we are to account for varying degrees of resistance in macro-sized objects. He suggests that since all material things resist pressure to some degree, they all have one or another degree of solidity. The only way to explain this range of solidity, or resistance to pressure, he claims, is by supposing that the constituent elements of all bodies are solid and thus not soft. Otherwise, there could be no bodies harder than the softest ones, for if the constituent elements *were* soft, then more solid bodies could never be composed from them. From this he concludes that all material things must be composed of maximally hard elements which, when put together with more empty space between them, yield softer bodies—and, when put together with less empty space between them, yield harder bodies.<sup>25</sup> As in the previous line of reasoning, Gassendi seeks to

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<sup>24</sup> O I 258b, 259b.

<sup>25</sup> O I 261a. Cf. *RN* I 565–570.

establish that some properties of macro-sized objects—variable solidity here, immutable materiality in his first argument—require an underlying atomic architecture. Unfortunately, the atomic account offered by the present argument also is not necessary to explaining the macro-property—for we can still have diverse degrees of resistance to pressure even if the basic elements of matter also range in degrees of solidity. Worse still, this account is not even sufficient to the task. Given that atomic size and the amount of interparticulate void are also variable factors, different combinations of these structural characteristics could yield identical degrees of solidity across the otherwise very distinctive macro-level objects they compose. Then varying atomic architectures is not sufficient for varying degrees of resistance to pressure in objects on the macro scale. These problems escape Gassendi, however, and he takes the existence of atoms to explain such shared properties of macro-sized objects—as well as those properties that differentiate them.

That the fixedly discrete nature of elemental particles must be defended does not escape him, though. This core claim underlying his atomism—that there are natural bodies which cannot be further reduced or divided—appears not just in these last arguments but throughout his matter theory. The importance he attaches to this claim can be seen in his first major atomist pronouncement, *De Apparente Magnitudine Solis humilis et sublimis*, where he tells us such bodies are

. . . corpuscles of an extreme smallness in which, by natural force, one may finally resolve any composed bodies; in such a way that if we imagine a corpuscle which by whatever natural force can still be taken apart, this is not a true atom, rather atoms are those particles in which [this body] is reduced in such a way that they are in the end themselves incapable of any reduction.<sup>26</sup>

To establish that some such material particles are truly elemental he needs to rule out further reduction and thereby say *why* matter cannot be infinitely divisible. If he fails to do so, it remains a viable corpuscularian option to hold that there is no smallest part of matter—as is characteristic of the non-atomist Stoic and cartesian matter theories. These are our only choices, Gassendi points out: either we cannot divide atoms at all or else they are infinitely divisible. If we

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<sup>26</sup> O III (AM) 466a (letter to Chapelain).

allow that atoms, though they are physical continua, have *some* discrete parts we open the door to their having *infinitely* many parts:

In effect, all continua either have actually no parts, or else have infinite parts. This is because, if you call actual parts those which are actually divided, the continuum assuredly does not have even two or three [parts], since [such parts] are [themselves] indivisible. If it [the continuum] actually has two of them because it is actually divisible in two, one must with all necessity say that there are actually infinitely many, since . . . it is similarly divisible into actually infinitely many parts.<sup>27</sup>

In this passage Gassendi appeals to a defining property of all continua—that any dividends by which a continuous magnitude is divisible are themselves further divisible. In the latter possibility he identifies, Gassendi apparently refers to non-physical continua such as lines; whatever parts we identify must in turn be composed of further parts (save for points which, being dimensionless, cannot be parts of larger magnitudes). In the former possibility he identifies, he refers to parts that are not divisible at all; this he maintains could only possibly hold of *physical* continua. Physical continua for Gassendi just are bodies containing no void—that is, atomic bodies. Atoms cannot be physically divided into *any* parts, then, given an absence of the void which alone would allow such division. In this way he secures the partless nature of atoms *ex hypothesi*—and for the purposes of his physical theory (and empiricist demands notwithstanding), it seems this should be sufficient.

Yet he offers additional arguments, drawing on ancient sources and contemporary debates alike, for rejecting the infinite divisibility thesis. Thus for example he borrows on historical arguments by echoing the Epicurean and Lucretian reasoning that there cannot be bound and finite wholes the parts of which are infinite, for otherwise there should be nothing to prevent the sum of the parts from being greater than the whole (indeed, they may be infinitely greater). This in turn would produce the paradox, Gassendi notes, that the parts of the world do not outnumber those of a mite.<sup>28</sup>

Gassendi expends his greatest efforts in denying matter's infinite divisibility, however, by focusing on the relevance of mathematical

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<sup>27</sup> O I 262b.

<sup>28</sup> O I 262a.

and geometrical considerations to physical accounts of matter's ultimate or near-ultimate particles. When, as in the passage quoted just above, Gassendi talks about physical and mathematical continua in the same breath, it seems he is content to admit such considerations—in keeping with a tradition stretching back to antiquity. Elsewhere, though, he identifies that application as an error underlying what he takes to be the mistaken notion that physical magnitudes are infinitely divisible.

This disparity in his attitudes is perhaps excusable on the grounds that such considerations may cut both ways. From the earliest Greeks on, puzzles concerning infinite divisibility in mathematics and geometry gave rise to two conflicting groups of intuitions about the possibility of infinitely dividing matter. On one hand, one pro-atomist perspective has it that paradoxes mounted against the possibility of infinitely dividing numbers or line segments are just as compelling against the possibility of infinitely dividing matter. In a different pro-atomist vein, the stipulation of mathematical points with no parts is plausibly suggestive of the possibility that ultimate physical particles may exist with no parts, also. On the other hand, an anti-atomist perspective has it that, if lines, planes, and three-dimensional abstracta may have infinitely many points, so too may physical objects. For instance, in *Against the Physicists*, Sextus Empiricus (presenting the Stoic view) suggests that, since we can always progressively divide abstract magnitudes (like lines or planes), magnitudes must be generally infinitely divisible, whether we are talking about spans of time or space, or extended bodies.<sup>29</sup>

Gassendi argues that Sextus has introduced a straw man. The ancient atomists, he maintains, would not have conceived of physical indivisibles in the same way as mathematical (really, geometric) points, to begin with. Such points are indivisible since they have no magnitude—with the result that continua, like lines or planes, unproblematically contain infinitely many of them.<sup>30</sup> But as Gassendi sug-

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<sup>29</sup> *SE, Adv. Math.* 3–4, II 123–142.

<sup>30</sup> In this vein, Gassendi distinguishes between mathematical minima, or points without dimension of which continua contain infinitely many, and natural minima, or three-dimensional entities which constitute bodies that cannot contain infinitely many elemental parts. In his view, they are related just in the sense that there are an indefinite number of the former in the latter (and this same relation holds between physical and sensible minima—those entities so small as to be at the limits of our perception): “The natural minimum is the atom itself, in which all reso-

gests, this means substituting physical indivisibles for mathematical ones prevents us from doing justice to geometry, for only the former have magnitude.<sup>31</sup> In general, whenever we employ elements of mathematics or geometry in physical accounts we must take care to distinguish them from their physical *faux amis*:

... It is not always permissible to transfer into physics whatever the geometers demonstrate abstractly. This can be established even from the fact that where the geometers themselves mention those parts of mathematics which have some connection with physics, they are often compelled to require entirely contrary suppositions. For example, Euclid himself in the *Optics* requires that a minimum angle be admitted. Similarly, Witelo accepts a minimum light which, if it is understood as divided, would no longer have the impulse [*actus*] of light. Here it is evident that they assume that in optics division is achieved as far as the minimum, whereas in geometry they would have permitted it to proceed to infinity.<sup>32</sup>

One problem with recycling *any* of the reasoning strategies of mathematics or geometry in the case of physical objects, Gassendi suggests, is that empirical and non-empirical demonstrations do not face the same constraints: “If the geometer demonstrates an apparently very easy thing, like the division of a line into two equal parts, do we imagine that this is an equally easy thing to realize and demonstrate in physics, that is, on the terrain of experience?”<sup>33</sup> Specifically, he points out, we do not have even precise enough tools to divide any physical object into two exactly equal parts. At first glance, this suggestion is not satisfactory. Gassendi appears to suffer by comparison with those of his contemporaries who embrace physical idealizations (or who, as Galileo, appeal to exemplary physical objects with their irrelevant flaws abstracted away)—and so allow

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lution meets its end, with which all composition begins, whereas the sensible minimum [extreme point of sensation] is that beyond which nothing falls under the senses, where a mite is of this sort, for example, with respect to sight. It follows from this that the atom is midway between the mathematical minimum and the sensible minimum: in the way that it is legitimate to suppose an indefinite number of points in atoms, it is legitimate to conceive of an indefinite number of atoms in the mite.” *O I* 160a.

<sup>31</sup> *O I* 263b–264a; *AN* 415. My recounting of Gassendi’s views on the applicability of mathematical reasoning to physical thinking (particularly in the *Animadversiones*) is indebted to Lynn Joy’s account (1986, 157–160).

<sup>32</sup> *AN* 416–417 (trans. Joy (1987), 160); *O I* 265b.

<sup>33</sup> *O I* 265b–266a; *AN* 414.

the precision in physics that is first found in operations like division on abstract objects.

To this sort of charge Gassendi has a ready response. The job of the physicist is to give an account of real objects, not fictive abstractions. Natural philosophy is limited, in a sense, to what occurs in the course of natural history:

It would seem that the physicist is thought to affirm the existence of a certain natural minimum [since] in the accomplishment of his task nature does not go to infinity. I say that the physicist must dedicate himself to what is perceivable, to what really exists in nature, even to things without making use of so-called abstractions conceived apart from matter.<sup>34</sup>

More specifically, what is wrong with applying mathematical or geometrical abstractions to physics is that we abstract away the ‘density and perseverance of matter’. As a result, we do not consider dimensions of magnitudes as basic to physical accounts and instead must introduce those dimensions by supplementary postulates.<sup>35</sup> Yet those authors who confound physics and geometry do not offer such postulates, Gassendi suggests. Hence it is quite natural, though ultimately in error, that they should have taken abstract objects such as idealized bodies to be infinitely divisible:

. . . because as yet there was freedom to imagine anything whatsoever on account of the banishment of matter [the mathematicians and geometers] supposed not therefore that any dimension is composed out of indivisibles, but that each dimension is composed from smaller and smaller parts of its own kind—a body from bodies, a surface from surfaces, and a line from lines—and hence that each one is always divisible into divisibles or, what is the same, into infinity.<sup>36</sup>

Their crucial mistake, in sum, is to consider magnitudes in the abstract instead of as physical features of the real world.<sup>37</sup> Gassendi

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<sup>34</sup> *O I 264a*.

<sup>35</sup> “. . . the assumption of the generation of dimensions was held as if only necessary for conceiving of the existence of these dimensions.” *O I 264b* (trans. Joy (1987), 162)).

<sup>36</sup> *O I 264b* (trans. Joy (1987), 163)).

<sup>37</sup> For Gassendi, this is as drastic a departure from the true ways of scientific pursuit as if we were to take as false any number of basic truths about what is necessary about the world: “If one considers quantity separated from matter, which is not [actually] the case, then one must suppose other things [are not the case] which are indispensable to nature and [which] never cease to be the foundation of all true and necessary conclusions.” *O I 265a*.

allows that, if we avoid this mistake, and stipulate that we are talking about magnitudes featuring those characteristics special to actual (non-idealized) three-dimensional objects, then there is a place for geometrical characterization and reasoning in physics. Indeed, physics *should* account in this way for objects that are divisible into possibly innumerable—though certainly not infinitely—many parts:

And [let us] affirm, then, that it is possible to transfer to physics the geometric hypotheses, but in a way and an objective such that, although there would be neither indivisibility of dimensions nor an infinity of parts but only an extreme slenderness and the impossibility of enumerating the parts, it would nevertheless be possible in starting from these hypotheses to obtain a greater precision.<sup>38</sup>

One further difference between reasoning about mathematical or geometrical abstracta and reasoning about real material objects is that only in the latter case could the limits on what is physically divisible be relevant to the limits on what is divisible in principle. In his earlier *De apparente magnitudine*, Gassendi calls this to our attention when he proposes that there may be bodies which, even if they have parts, are physically indivisible anyway—in contrast with mathematical points, about which we may not concede that they have parts at all:

That corpuscles of this kind exist, Democritus and Epicurus prove by this fact: That if the mathematicians suppose some bodies that are divisible until infinity, they nevertheless do this by starting from hypotheses about things stripped of real existence, like a point without parts, a line without thickness, etc. . . . But nature, in dividing or taking apart a body into particles of which it is constituted, only goes until a determinate degree, and never breaks up infinitely or indefinitely. From this

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<sup>38</sup> *O I* 265b. The sort of precision Gassendi has in mind here seems to be not so much the product of geometry as of arithmetic. In the example he offers, he rehearses the well-worn atomist proposal that we might reliably guess at the number of particles forming the diameter of a body at the lower limit of perception by judging the number of (presumably larger) parts which form the diameter of a distinctly larger body, and then judging the ratios between the two bodies: “Thus Archimedes assumed that the diameter of a poppy seed comprises 10,000 particles not because any art could discern so many parts in such a small thing, but because by applying this reasoning to a greater quantity, the proposition would have followed more closely the less he erred through the neglect of this sort of small particle.” *AN* 417–418 (trans. Joy (1987), 161); q.v. *O I* 265b. The clause ‘sed ut maiorem in molem ratiocinatione translata’ is better understood as referring specifically to application of reasoning to greater numbers, or a greater magnitude, rather than to a greater quantity in some more general sense.

it is clear that we speak of atoms not, as it is popularly believed, because these are mathematical points that are indivisible by the absence of parts, but because, even though these are real small bodies, there is no natural force at all by which they may be cut or taken apart.<sup>39</sup>

If it is not physically possible to divide matter past a certain limit, then bodies of sufficiently small size have no physically isolable parts. The conceptual division of matter, by contrast, may not carry any limits—but also has no bearing on the limits of their physical division. In short, puzzles over infinite divisibility of abstracta could not be relevant to the question of infinitely dividing matter.

At the heart of Gassendi's worries here is the concern that we take loose affinities between our accounts of physical and abstract objects as the basis for treating such objects of, for example, physics and geometry, as if they share the right sorts of features that would warrant talking about either with equanimity. Not all comparative judgments are bad: as we have seen (chapters two and six), Gassendi makes frequent appeal to analogy, especially in the context of hypothetical reasoning. In the present sort of case, though, Gassendi consistently opposes such appeals. More than a decade before the *Animadversiones*, he dismisses Poysson's contentious proposal that we might move seamlessly from discussing mathematical points to discussing the smallest extended entities as though they were relevantly similar or even plausibly identical.<sup>40</sup> Even in the context of that ear-

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<sup>39</sup> O III (AM) 466a (letter to Chapelain).

<sup>40</sup> Poysson's query concerned whether we might better understand the nature of an extended thing having parts by imagining that we can assign magnitude to ostensibly partless mathematical points. The query quickly made the rounds of Gassendi's intellectual milieu, the circle of Marin Mersenne's correspondents. Mersenne forwarded the 'Poysson problem' to Peiresc, in a letter of October, 1635:

One question. Is there a demonstration perfect from a logical viewpoint, a mathematical viewpoint, and a viewpoint of knowledge from the senses, proving that there exists a given magnitude with extension, and which in a given time and place can be found in a truly mathematical point, in a point stripped of parts such that this magnitude would have in this point exterior parts? (*TdL* XIX 149)

Fast on the heels of receiving word of the problem (via Peiresc), Gassendi offers this dim assessment:

... I do not see at all that if many mathematical lines which are only in the imagination may meet one another in a mathematical point which is also only a supposition of mathematicians, at the same time many physical, sensible, and bodily lines can be found in a point which is mathematical and not physical, sensible, or bodily (consequently always having some size, however imperceptible to the senses). And, certainly, I am a little surprised that this serious man



lier controversy Gassendi distinguishes what are mere abstract posits with no magnitude from what he takes to be extended bodies endowed with magnitude. In the later *Animadversiones* and *Syntagma*, it appears as a concomitant claim that an infinite divisibility thesis is indefensible if it relies on this sort of failed analogy between physical and abstract objects.<sup>41</sup>

A further tack taken by Gassendi addresses a defense of the infinite divisibility thesis based on the claim that an essential feature of matter is its being extended. This defense suggests that as long as something is extended we should be able to conceive of its parts; thus it is inconceivable that anything, however small, would be extended though we could not continue to divide it into smaller and smaller parts. The parts of macro-sized objects are divisible, so why should the parts of micro-sized objects not be divisible, too? In response Gassendi argues that divisibility surely cannot be a feature of bodies we stipulate as not having divisible parts to begin with. Once again, the infinite divisibility thesis fails by the constraints of a physical assumption, namely, that even if we concede that atoms have parts, then unlike the separable parts of macro-sized objects, it may not be possible to break up atoms into those parts.<sup>42</sup> Such parts may simply be the non-separable elements of a physically continuous

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[Poysson] who suggested previously that light is a corporeal substance, afterwards would have it that many rays—that is, many bodies—meet each other in the same mathematical point, that is, penetrate one another and be in the same place—which is not possible by nature. (*Fonds Dupuy, BnF, 688 folio 90*, letter of November 30, 1635)

<sup>41</sup> Gassendi addresses this issue in discussing attacks on the finitude of divisibility proposed by Epicurus:

Surprisingly, there were not only some from ancient times who attacked Epicurus as if he had held that the division of a magnitude is terminated in certain mathematical points; but there were also learned men from more recent times who inveighed against him with entire volumes as if he had said that bodies were constituted from surfaces, surfaces from lines, lines from points, and accordingly bodies and indeed all things from points, into which bodies and all things were in the same manner resolved. It was amazing, I say, since if they had been willing to attend in the least, they could have noted that those indivisibles, in which Epicurus held divisions to be terminated, are not mathematical points but the smallest bodies. For he made magnitude, none of which is admitted in a point, a property of them and, what is more, he made an endlessly variable figure, such as cannot be conceived in a point lacking magnitude and parts, a property of them. (*AN* 414 (trans. Joy (1986), 156); cf. *O I* 263b–265a).

<sup>42</sup> Gassendi embraces this view as a matter of following Epicurus, who suggests that atomic parts have been always joined together, and therefore will remain so:

entity. If such seems impossible, this may be a limitation of our conception or description—by comparison, we can easily conceive of a two-dimensional plane as having two facets even though they are inseparable.

Indeed, for Gassendi, there are two kinds of inseparable parts or aspects—‘atomic’ and ‘measurable’ minima. In brief, the first kind encompasses all physically inseparable aspects, in any atoms; the second kind encompasses the smallest conceivable parts for which we can speak of any measure, in those atoms with determinate shapes.<sup>43</sup> This latter kind is more closely defined as follows: for all atoms we stipulate as having particular edges or protrusions, we can say what their angles would measure, for example, given the right instruments. Naturally, we cannot measure actual micro-sized angles—hence measurable minima are “*such that we conceive* the extremity of an angle in a pointed atom.”<sup>44</sup> For atomic minima, there is an analogous story relative to all parts or aspects of atoms: we should be able to conceive of atomic parts, like a top or bottom half, without requiring that they are actually separable or even that we may conceive of their separability.

This last point indicates that indivisibility of atoms is indispensable to the theory; other features of atoms may not be so. If we *could* conceive of such parts (as we attribute to atoms) as separated, then this is because God could have created atoms that much smaller—in which case it turns out to be false that those particles to which our current conception commits us have no separable parts.<sup>45</sup> So much the worse for the current conception, then: if God could have created smaller atoms, then the particular size of atoms as we think of them does not matter as long as they have no separable

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... [Epicurus] introduces a distinction between the parts that constitute a sensible body and the parts of which the atom is the set; this is because, having been separate, the former at a given moment are found conjoined, [and] as well can be separated after having been conjoined; whereas the latter, having always been conjoined, have never formed a union from separation, and could no more be resolved in separate parts. (*AN* 419; *O* I 259b)

<sup>43</sup> *O* I 268a–b. There are, in addition, *sensible* minima—the smallest objects or parts we can sense.

<sup>44</sup> *AN* 45 (emphasis added); cf. Rochot (1944), 174.

<sup>45</sup> This is not the incoherent suggestion that whatever the smallest particles are could have had separable parts (in which case they would not actually have been the smallest particles), but that what the smallest particles actually are by the lights of the theory could have had separable parts.

parts. That atomists place a higher premium on the inseparability of parts than on the size of atoms, however, raises an old problem. As one ancient argument goes, if the absence of internal void blocks the separability of parts so that atoms as individual plenums have inseparable parts, then we could also have absurdly large atoms as long as they contain no internal voids. We would only have to insure that everything else in the universe could still be generated from such atoms. Gassendi responds to this problem by insisting that other limitations come into play: no such generation could be possible since even the smallest familiar macro-sized objects dissolve into finitely many parts. Hence it must be that all God and nature have with which to generate the world's multifarious legions is atoms of a rather *small* size. Speaking once again of the mite (*acari*), he notes:

We imagine all these parts without the whole with which nothing that nourishes itself, lives, senses, imagines, or moves, can subsist. And we understand that nature must be able to distinguish, put in order, and organize into a whole, innumerable tens of thousands of particles to form a small organism which to the naked eye is like a point. Nevertheless, since nature cannot go to infinity in its dissolution, but stops finally at something non-decomposable which is the [physical] minimum, this is what philosophers have generally called the atom. In this sense, it is convenient to call as atoms those extremely small and non-decomposable particles—of which we can conceive that many tens of thousands exist in one mite. If nevertheless we admit that fine membranes are formed from only one layer of atoms, what a large number—what an innumerable quantity—must be brought together before we arrive at the thickness of a mite or of a spider's web.<sup>46</sup>

Given that the smallest parts of the tiniest creatures have an atomic structure, the atoms composing them must be smaller still and great in number. Indeed, these atoms must be of roughly uniform size, such that they may compose the mite's smallest structures—starting at the lowest level of fine membranes one atom thick. Such attributes as size are addressed in detail in Gassendi's account of atomic properties.

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<sup>46</sup> O III (*AM*) 426a (letter to Liceti).

### 3. *The Contours of Gassendi's Physical Atomism*

One consequence of the tininess Gassendi attributes to atoms is that it should be a quixotic enterprise for him to seek empirical foundations for his atomism, for in his times there is not the barest hint of perceptually-derived knowledge of anything so small. There is, he thinks, an empirically viable source of at least some claims concerning atoms—as I indicate in chapter twelve, this is the indirect data of indicative signs. Yet the general tenor of his characterization and defense of physical atomism signals a departure from his customary empiricism. As is so in his defense of an indivisibility thesis, Gassendi relies foremost on reason, not experience, to account for the origin and quantity of atoms and what he takes to be their essential and inessential properties, their internal impetus, motion, and causal role, and their contribution to the motions and qualities we attribute to macrophysical objects. He is hardly to be faulted in this regard—not only is direct empirical evidence unavailable, he is also responding in kind to those of atomism's critics for whom the use of reasoned argument without appeal to empirical force is common strategy. Among these critics, he is primarily concerned with responding to Aristotle, the Stoics, Descartes, and the early Christian writer Lactantius (250–317 CE).<sup>47</sup>

#### a. *The Origin and Quantity of Atoms*

One of the more lucid aspects of Gassendi's corpuscularian picture is his account of the origin of atoms. In response to Lactantius's worry that the ancients could not give any such account because they believe atoms to be eternal (*On the Anger of God* §X) Gassendi answers that we may simply stipulate that atoms are created by God.<sup>48</sup> It is possible, he admits, that God could have made macro-sized objects without making their constituent atoms. But since our

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<sup>47</sup> Q.v. Lactantius, *The Divine Institutes, Books I–VII. (De Divinis Institutionibus)*, trans. Sister Mary Francis McDonald (Washington, DC: Catholic University Press, 1964).

<sup>48</sup> One incidental result of this stipulation, coupled with the finitude of Creation, is a theological argument against the infinite divisibility thesis: if bodies were infinitely divisible, then one corpuscle could beget infinitely many newly created corpuscles; but given that there are only as many corpuscles as God creates they cannot be infinitely divisible.

physics tells us such objects can always be resolved into those constituents, to have created them as composites amounts to the same thing as having created the atoms at that point, too.<sup>49</sup> Hence we may as well incorporate the origin of atoms as a minor adumbration of the Creation story. Though this account will not satisfy the ancient atomists, Gassendi points out that they already have a viable non-Christian story to fall back on. If atoms are the primary stuff of matter, they could not have been created from anything else. Yet if they could not have been created from anything and by the Parmenidean dictum they were not created from nothing, then it is not only plausible but also necessary that they exist from the beginning of time lest they not exist at all.<sup>50</sup> One intriguing aspect of this last response is that while Gassendi clearly wants a theologically palatable atomism, he also tries to answer critics of atomism in terms with which the ancients would have felt comfortable. This is further evidence that he is interested primarily in a sustainable atomism whatever our background nonscientific views, and only secondarily in developing an atomism acceptable to Christian belief.

An issue which is less clear is how many atoms God created in order to form the universe. Just as matter cannot have infinitely many parts there cannot be infinitely many atoms—for at least one common reason, namely that God's creation (unlike God) must be finite.<sup>51</sup> And whereas Gassendi recognizes the folly of trying to come up with any specific numbers, he insists there are no obstacles to God creating sufficiently many to constitute the components of all extant matter. In particular, *contra* Lactantius, it is neither the case that any knowable number of atoms cannot possibly suffice to constitute all the matter of the universe, nor that it is unintelligible to suggest that tiny atoms could constitute 'immeasurable masses'.

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<sup>49</sup> *O* I 280a; *B* 400.

<sup>50</sup> *O* I 281b; *B* 404–405.

<sup>51</sup> *O* I 273a. The argument here is that finitude is a privation, and God is perfect hence suffers no privations, whereas all of Creation by contrast suffers privations. Hence God is infinite but Creation finite. Several dissenting moves are possible. For one, it might be thought that Creation, being a divine product, can no more suffer privations than the divine Creator (though this move makes a mystery out of imperfections generally). For another, it might be held that finitude is not a privation at all but simply a contingent state of affairs which does not reflect a loss or lack of anything. Then the quantity of matter, atoms, or other parts of matter is finite merely as an accidental feature of the world.

Regarding this last point Gassendi proposes that we do not have any difficulty abstractly dividing enormous masses into their constituent parts (where the smallest, according to this theory, are atoms) so we should have no more difficulty adding up atoms to produce those same masses. Regarding the first point, he proposes that in principle there is no problem in expressing the number of atoms sufficient for constructing the whole universe. To see this, we take some estimate of the number of atoms which should be present in small particles—this is presumably a knowable number—and multiply such numbers by some large number we think represents the great quantity of such particles or larger objects. This, too, will be an expressible number. If we think the number of small particles is higher, then we adjust the second figure higher, but the product will still be expressible, and so on for any second figure we pick. Hence (by an unstated application of mathematical induction) the number will be expressible no matter how many supra-atomic sized bodies we think there are in the universe.<sup>52</sup> That Gassendi has no conception of what such numbers would be is immaterial to his next proposal that populating the world with atoms alone yields a denumerably finite number given the denumerably finite quantity of macro-sized objects so constituted.

b. *Properties of Atoms and their Aggregates, and the Role of Atoms in Macro-Physical Properties*

Enumerating atomic properties is a far simpler affair, at least at first glance. Gassendi distinguishes between two sorts of atomic properties: those inherent in and essential to all individual atoms, and those which are a feature of atoms in groups. To begin with, his list of inherent atomic features, which closely follows Epicurus's list, includes: extension, size (*moles*), shape (*figura*), weight or mass (*pondus*), and solidity (*soliditas*). Generally, relative to each of these features all atoms resemble one another, there being a relatively limited range of sizes and weights.<sup>53</sup> One exception is shape: in order to account for

<sup>52</sup> *O* I 282a–b; *B* 406–407.

<sup>53</sup> Regarding size, q.v. *O* I 268a–b. Weight is more controversial given that Gassendi correlates it with motion, and considers the latter to be uniform; q.v. *O* I 278b; *AN* 422. Elsewhere, though, he makes brief reference to weight, together with size and shape, as those qualities that differ across atoms; q.v. *O* III (*SPE*) 16.

tremendous variety among natural objects, Gassendi claims, there must be very many different types of atomic shapes (though not infinitely so), and many tokens of each type (again, not infinitely so).<sup>54</sup>

Another notable feature of this list of properties is that it signals Gassendi's rejection of the cartesian view that extension is sufficient to characterize what is essential to the least bit of matter. Descartes's view is wrong, then, for the same reason that the Scholastics are wrong to talk about featureless matter in the context of physical theory.<sup>55</sup> As Gassendi argues, while we might abstractly conceive of matter with one feature such as extension—or none at all, per the Scholastics—matter cannot actually come into existence without the features that God assigns at Creation, namely, size, shape, weight, and solidity.

A further difficulty with considering extension as the sole essential feature of matter or its constituent elements is that it does not, as Gassendi notes, distinguish matter from void. Minimally, he can use solidity to distinguish the two, given that he just understands 'having solidity' as the same thing as 'containing no void'. But stipulating that atoms must be solid is also felicitous for Gassendi because it helps him establish that atoms have resistance and impenetrability (*αντιτυπια* or *antitypia*). In short, whatever travels through pure void meets no resistance, from which it is inferred that a lack of void accounts for their resistance; and interparticulate void is what

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The range of atomic size must be limited, in any case. For if atoms were significantly greater in size than the smallest ones, they would not contribute to the structure or behavior of bodies they compose either uniformly or in the ways we infer from our observations.

<sup>54</sup> Gassendi suggests we can expect the variety of shapes in atoms that we find in shapes of macro-sized objects like leaves or grains of wheat (*O I 270b*). This analogy is clearly limited to shape—if it was thoroughgoing, we should also expect a similar variety in atomic sizes or yet other properties.

<sup>55</sup> Descartes's views are famously more traditional than he pretends. Here his ascription of a single essential characteristic to matter—pure extension without any other determinate features—is but one feature more than what is on offer from the Aristotelians and Scholastics, who propose that everything is composed from featureless matter to which the introduction of form brings all other determinate characteristics. The addition of this one feature, to be sure, is a drastic increase over *no* features, yet there is in both views a common minimalism. As a consequence of that drastic difference, though, Descartes is entitled to call his basic matter (stripped of inessential features) a "real, perfectly solid body" (*Le Monde, AT X 33*; *The World and Other Writings*, Stephen Gaukroger, trans. and ed. (Cambridge; New York: Cambridge University Press, 1998), 22). This view of basic matter is wholly unavailable to the Scholastics; thanks to Sophie Roux for this point.

permits penetration of one body by another, from which it is inferred that a lack of (this kind of) void renders a given body impenetrable. Moreover, that atoms are solid suggests that they are indestructible, which is necessary for them to persist as the material substrata; and that they are indivisible, which is required of them as the ultimate material elements.<sup>56</sup>

Yet the essential feature of atoms which does the most work in Gassendi's physics—and also generates the most difficulties—is their inherent weight, which gives them an intrinsic, natural *tendency* to move such that their rest is either provisional or else an illusion. I discuss atomic motion and causation at length in chapter ten, but the few primary aspects of Gassendi's view merit mention in this context. For one, the weight of atoms lends those capacities necessary for “. . . moving, . . . imparting motion to others, . . . [and] rolling about,” which in turn endows atoms with the robust set of further capacities to “. . . disentangle themselves, to free themselves, to leap away [*prosiliendi*, to spring out], to knock against other atoms, to turn them away [*retundendi*, to check], to move away from them, and similarly [they have] the capacity to take hold of each other, to attach themselves to each other, to join together, to bind each other fast . . .”<sup>57</sup> For another, however, it must be the general tendency of atoms to move in straight lines given that—unlike what the Epicurean tradition says (though perhaps as Epicurus himself would say)—the atoms here do not feature the *clinamen*, or swerve. Finally, there is at least a suggestion of vitalism or animism in Gassendi's proposal that God endows atoms with a robust set of capacities for moving themselves.<sup>58</sup> Even in cursory review, these tantalizing claims suggest

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<sup>56</sup> *O I* 266 ff.

<sup>57</sup> *O I* 280b; *B* 400–401. Gassendi actually uses the term *vis*, or what is usually translated as ‘force’ in this context, but it is clear that he is talking about a ‘capacity’ or ‘power’ which enables atoms to move in these various ways, and not about ‘force’ *per se*, unless it is understood purely in terms of ‘potential’. Naturally, this does not prevent him from subsequently referring to the very same *vis* in terms of one or another concept of force. As Westfall (1971) notes, it is common for physical theorists of the period to use the same term in different places to pick out a variety of meanings, and this is markedly the case with *vis* in much early modern physics. I discuss Gassendi's views on atomic *vis* in chapter ten.

<sup>58</sup> There is also at least an appearance of teleology or ends-driven design in the proposal that God endows atoms with these capacities for motion at Creation so that they may have what they need to move in ways required for fulfilling their God-given purpose. In Gassendi's discussion of the atoms God designates as elements of organisms' ‘seeds’, he seems to offer such a view of purpose: “. . . from



significant and controversial consequences of stipulating that atoms have inherent weight and resulting tendencies to motion; I discuss some of these consequences in chapter ten.

To round out the present overview of relations of physical properties and atoms, two other sets of properties require explication: those characteristic of atoms in groups, and those of macro-sized bodies existing only in virtue of the properties and relations of their constituent atoms. Regarding this first set, Gassendi follows Democritus and Lucretius in holding that such properties include the position of a group of atoms relative to neighboring spatial regions (*situs*), and the arrangement of a group's members relative to each other (*ordo*).<sup>59</sup> In addition, Gassendi proposes that many atomic groupings constitute specific sorts of molecules (*moleculae*) or concretions (*concretiumculae*) which feature special aggregate properties that in turn underlie many of the familiar qualities or properties of macro-sized objects. Like atoms, these molecular structures serve as elemental building blocks of macro-sized objects, though on a larger scale and in a more dedicated fashion. Gassendi analogizes the different levels of material elements to the elements of language:

As letters are the elements of writing and from letters are formed first syllables, and then successively words, phrases, and speeches, so also atoms are the elements of all things. From the atoms the smallest molecules are joined together first, and then successively somewhat bigger ones, still bigger ones, the finest and the coarsest bodies, and finally the biggest bodies.<sup>60</sup>

Molecules are *dedicated* elemental structures, with specific capacities for forming one or another types of macro-structures.<sup>61</sup> Thus, whereas the classical Epicurean view suggests any macro-sized object may be formed from any elemental bodies (namely, atoms), Gassendi holds that particular macro-structures often, if not generally, come into

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selected atoms he fashioned the first seeds of all things, from which later the propagation of species would occur by generation." *O I* 280b; *B* 401.

<sup>59</sup> In this regard, Gassendi cites the ancient analogy to the spatial arrangement of letters, whereby two letters structurally alike yield very different possibilities for constructing compound entities (words, in the case of letters) in virtue of their positions. The examples he offers are Z and N (after Aristotle's discussion of Democritus, where the examples are I and H; q.v. *Metaphysics* I 4 985b 16–18),  $\gamma$  and  $\lambda$  (per Philoponus), and b, d, p, and q (his own instances); q.v. *O I* 367a; *B* 426–428.

<sup>60</sup> *AN* 209–210, trans. van Melsen (1960, 92).

<sup>61</sup> *O I* 281b–282a.

being only because the right sorts of molecules come together. Of course, this is an interesting structural requirement only if it is not the case that any molecules can be formed from and resolved into any atoms, and Gassendi indeed insists not all molecular combinations are possible. Rather, molecules are specially brought together by the complimentary motions of and connections between such component atoms as stand in the right relations and feature the right protrusions.<sup>62</sup> Atoms may be held together by hook-and-eye protrusions, or by pressure of one set of atoms against another, or else by an absence of those peculiarly round and smooth sort of atoms which are noncohesive.<sup>63</sup> Further, molecules once formed are not easily resolved into their constituent parts, though they are divisible in principle,<sup>64</sup> which suggests that nature fashions many particular sorts of macro-sized objects not by the chance interactions of randomly available atoms but by the interactions of more complex structural elements which are generally already in place. This eliminates or at least minimizes the problem, posed by Lactantius and others, that forming standard sorts of highly organized macro-sized objects from their more basic atomic components is highly improbable.<sup>65</sup> Thus, for example, Gassendi suggests (following Lucretius) that structures of living organisms are composed of ‘seeds’ of life, or animate sorts of atomic aggregates:

We cannot say absolutely that sensible beings are made from insensible elements, but rather that they are made from things that, *though*

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<sup>62</sup> *O I 475a*. Henk Kubbinga, following Bloch, suggests that Gassendi contributes to an early seventeenth century trend—also found in Jungius, Beeckman, and Basso—of promoting a corpuscularianism in which a modern (that is, post-nineteenth century) concept of the molecule is a central and novel feature; q.v. Henk H. Kubbinga, “La Théorie Moléculaire chez Gassendi”, in *Société Scientifique* (1994), 283–302; and Bloch (1971). While it is certainly a modern notion that special physical and chemical properties emerge in such atomic aggregates, the purely mechanical nature of these molecular bonds—that is, that they are realized entirely by contact action—militates against Kubbinga’s suggestion. The familiar modern molecular concept, after all, has it that non-mechanical forces bind atoms together. Moreover, Gassendi’s notion that all forces are mechanical at root precludes any attempt to construe him as holding the modern view.

<sup>63</sup> According to Gassendi, that some atoms *are* rounder and smoother than others helps explain variations in the rates of such physical phenomena as evaporation and melting across types of substances. For example, he suggests that water vaporizes more quickly than oil because the constituent atoms of water are rounder or smoother than those of oil). *O I 281b*; *B 405–406*.

<sup>64</sup> *O I 260a*.

<sup>65</sup> *O I 282b*; *B 407–408*.

*they in effect do not [themselves] sense nevertheless contain the sensory principle, just as the principles of fire are contained and hidden in the veins of stone.*<sup>66</sup>

A further example of such specialization on the level of atomic aggregates is the distinctive crystal form of those molecules that serve as the structural bases of a diverse group of macro-sized stuffs including sugar, salts, and alum.<sup>67</sup> Gassendi proposes that this sort of structurally basic molecule appears only when the right kinds of individual atoms aggregate in such a way as to yield those crystalline features, for (apparently) no single atoms have the requisite structure.

The appearance of special properties like crystalline form when two or more atoms come together as molecular units is only one such phenomenon where supra-atomic properties predictably result from the combinations of individual atoms. Another, more familiar phenomenon of a like sort is the appearance of particular qualities among macro-sized objects, which Gassendi explains by appealing to dispositions and states of their constituent atoms or atomic aggregates. He outlines four broad sorts of atomist accounts of the qualities of macro-sized objects, each corresponding to a particular sort of macro-level quality—in his term, ‘modes of substances’. To begin with, there is the sort of quality he considers basic to all material objects—wherein all macro-sized objects have one or another such qualities. These are produced directly by the inherent and defining properties of select individual corpuscles. Such qualities include what the Aristotelian matter theorists of his day (along with the practicing alchemists and iatrochemists) call the elemental principles: heat, cold, dryness and wetness. Accordingly, it is the calorific, frigorific, dry, and wet atoms—distinguished by their shapes and sizes (for example, calorific atoms are small, round, and move rapidly; frigorific atoms are pyramidal, sharp-pointed, and move slowly)—that yield the familiar corresponding macro-phenomena when the right number of such atoms come together. Fire, for example, occurs when sufficiently many calorific atoms are brought together.<sup>68</sup> A second

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<sup>66</sup> *O II 349* (Gassendi’s italics). One upshot of this view is the strikingly prescient notion that there are organic and inorganic molecules. The distinction for Gassendi, though, is not hard and fast but along a continuum, for he shares the view, common for his times, that minerals also have some degree of animation.

<sup>67</sup> *O I 271a*. I discuss the putative empirical evidence for this case in chapter thirteen.

<sup>68</sup> The presence of heat atoms is neither a necessary nor a sufficient condition

sort of quality, which includes rarity, density, firmness or cohesion, and fluidity, is produced by the specific states, combinations, or interactions of multiple atoms. For example, whether in air, flame, or liquid, fluidity on the macro-level results when atoms are aggregated loosely with few points of connection. Firmness or cohesion on the other hand results when atoms are aggregated tightly with many points of connection, including connection by the aforementioned hook-like protrusions.<sup>69</sup> Still other qualities are also defined by the relations among atoms, but are further determined by the context of the given body containing them; these include color, odor, taste, softness, hardness, flexibility, tractability, and ductility.<sup>70</sup> Finally, there are the capacities of macro-sized bodies that somehow arise from the form or the whole of a body,<sup>71</sup> which Gassendi construes as qualities produced by the spatial arrangements characteristic of the union of their distinct corpuscles.<sup>72</sup> These are primarily capacities for special influences or powers (including the attractive powers of gravity and magnetism) and capacities for susceptibility to the same. Insofar as these capacities yield particular consequences not manifest to the senses, Gassendi refers to them as ‘occult’ qualities. The ‘occult’ qualities that particularly interest him are those that, relative to particular organic contexts, are curative or harmful—including those qualities

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for heat—such atoms are also present in the pores of bodies that are not themselves hot, and heat may also be generated by friction or putrefaction (*O* I 394f; and following Epicurus, q.v. *SPE* 23). This generous attention to flexibility, however, unfortunately makes Gassendi’s special calorific qualities of atoms superfluous.

<sup>69</sup> *O* I 402–405; cf. *Bernier* III 135–140. Dijksterhuis points out that in seeking this kind of corpuscular account of cohesion Gassendi is practically alone in this period (1961, 428). Thus, by contrast, Descartes sees cohesion as a result of inertial motion plus the relative rest of parts of space and matter—so that a body remains cohesive to the degree that there is no impact with other bodies—and Galileo (following one Scholastic view) holds that cohesion results from resistance to the vacuum.

<sup>70</sup> For color, q.v. *O* I 432–441; for odor and taste, q.v. *O* I 409–415; and for softness, hardness, flexibility, tractability, and ductility, q.v. *O* I 405–409.

<sup>71</sup> The distinction between these last two sorts of qualities is loosely analogous to the modern distinction between tertiary and quaternary structures of proteins, where the former are three-dimensional configurations (as in folds of  $\beta$  chains of hemoglobin), and the latter are spatial arrangements formed by aggregates of distinguishable units (as in four such  $\beta$  chains joined to form an oligomeric protein).

<sup>72</sup> A thorough list of properties for which Gassendi thinks we should be able to devise atomist causal accounts also includes: transparency and opacity, coarseness and fineness, smoothness and roughness, elasticity, malleability, fragility, fissility, evaporation and condensation, liquefaction and solidification, sound, and light.

that enable plants to serve as purgatives, venoms, or antidotes.<sup>73</sup> In sum, an atomist account of how macro-sized objects have their properties is available for all such ‘macro’ properties as are directly produced by special properties of individual atoms, are produced by atoms in modest combinations, are dependent on the context of a given containing body, or arise from the relations of atoms in the structure of a particular sort of body.

All these accounts rely on a commonplace of seventeenth century metaphysics, the distinction between primary and secondary qualities. The standard form of this distinction—as fashioned by ancient atomists and rediscovered by the early moderns (Gassendi included)—suggests that qualities of macro-sized objects we associate with qualitative perceptions are actually unreal, ephemeral products of the real and lasting qualities found in matter’s basic elements. It is merely accidental that some particular qualities are perceivable. Thus it is a natural extension of the standard primary/secondary distinction to describe *all* qualities of macro-sized objects—perceivable or not—as the products of qualities marking corpuscles and corpuscular structures. Thus not only do we perceive a ball as red because of the right sorts of interaction between atoms of light, the ball, and our optical apparatus; it is also so that we take the ball to be fragile or flammable because we think the right sorts of atomic phenomena obtain—without the benefit of being able to perceive those qualities. Moreover, on general nominalist grounds, it is also a natural extension of this extended, global account to suggest that *all* macro-phenomenal qualities are unreal and if any qualities are real, only the corpuscular ones are. Indeed, given Gassendi’s equitable treatment of perceptible and imperceptible qualities, he needs such a global account to generate the foregoing sorts of causal stories and avoid runaway inflation of real qualities or properties.

In the context of this global account, then, the perceptible or ‘secondary’ qualities constitute a special case, where one or another story is told about how they are produced by the interaction of our sensory organs with ‘primary’ qualities of external bits of matter. For example, Descartes holds that such secondary qualities simply emerge

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<sup>73</sup> *O* II 160–168; cf. *Bernier* V 4 237–239 and Margaret J. Osler, “How Mechanical Was the Mechanical Philosophy? Non-Epicurean Themes in Gassendi’s Atomism”, in Lüthy, Murdoch & Newman (eds.) (2001), 423–439.

from the mechanical motions of those corpuscles said to bear the properties in question. This is particularly clear in his accounts of light—which he claims we perceive as a consequence of pressure on our eyes—and color perception. Gassendi, for his part, offers a modern adaptation of Epicurean and medieval species theories. He proposes that our visual perceptions of secondary qualities result from perceptions of *material* species, that is, aggregates of light corpuscles representing the qualities in question and traveling in streams emitted by the macro-sized bodies to which we precritically ascribe such qualities.<sup>74</sup> As I note in chapter three, Gassendi holds that this sort of species-transmission must occur in order that we perceive such visual elements of an object as its colors. As per the standard primary/secondary distinction, what we perceive as qualities of mid-sized objects arise from (qualities we associate with) the configurations of their parts, and ultimately from the atoms constituting those parts. Gassendi simply requires in addition that some representation of or information about those configurations is transmitted from the objects to our sensory organs. Hence, for example, while particular colors arise from distinct atomic configurations and positions, and we can change the colors of a thing by altering those atomic qualities (as through chemical reactions), we only *perceive* the colors of a given object if we perceive the species that object transmits with just such information.<sup>75</sup>

There are, famously, a series of problems with the primary/secondary qualities distinction, and Gassendi's version does not escape these. To take one instance, the sort of explanatory account he bases

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<sup>74</sup> Such emission or 'effluxus' (*aporrhoias*, or ἀπόρροιας) of particles is not limited to material species, but is also a feature of Gassendi's account of attractive powers; q.v. chapter eleven. His appeal to atoms cast off from their originary body is a common theme of mechanical explanation in early modern matter theory; q.v. Eileen O'Neill, "Influxus Physicus", in *Causation in Early Modern Philosophy: Cartesianism, Occasionalism, and Preestablished Harmony*, ed. Steven Nadler (University Park: Pennsylvania University State Press, 1993), 27–56; and Gordon Keith Chalmers, "Three Terms of the Corpuscularian Philosophy", *Modern Philology* 33 (1936) 3: 243–260.

<sup>75</sup> O I 367. While this is a small addition there is arguably nothing simple about it: What exactly is a 'representation of' atomic qualities? In what form does 'information about' atomic qualities come? If light is corpuscular as Gassendi proposes, and we perceive it (for example) whenever it bounces off other objects and hits our eyes (see chapter three), then how do we perceive light's qualities—such as intensity or duration? Surely this does not entail *additional* species bearing further information.

on this distinction fails to say why we perceive secondary qualities of macro-sized objects, and not the primary qualities of atoms. Gassendi recognizes this shortcoming and suggests, quite reasonably, that we do not perceive the primary qualities because atoms that bear them are subperceptible given our particular sensory apparati. Dijksterhuis protests that this does not tell us *how* mechanical interactions of these subperceptibles with our sensory apparati produce our particular sensations of macro-sized objects. Yet (as I outline in chapter three) Gassendi does offer a mechanical account of visual sensation and attempt to explain how other forms of perception work. Nonetheless, his account fails to satisfy empirical constraints, for he builds it largely on guesswork about the functional morphology of the relevant apparatus and corpuscular structures underlying the corresponding secondary qualities. Moreover, a further question may be raised as to what sort of perceptions we would expect to have of primary qualities had we the appropriate epistemic access—in particular, it is not obvious that we should expect to our senses to be influenced by such qualities in the same way that they are by familiar, secondary qualities.

Another sort of difficulty is that, while Gassendi's thoroughgoing atomism suggests all macro-phenomenal qualities arise from the more fundamental qualities of atoms, he does not even attempt to explain how we may ascribe such qualities as we do not and cannot perceive. For perceptible qualities such as color, the perceptual vehicle of the material species transmits representational content, whereas for non-perceivable qualities such as cohesiveness, there is no such phenomenon. Hence it is not possible to attribute our awareness of, for example, a body's cohesiveness to a representational species the body emits. Rather, in ascribing such dispositional qualities (and any others lacking representational content) we can only rely on inferences from whatever ancillary perceptual information is available to us. This is a consequence of Gassendi's view that all knowledge is from the senses. Yet he does not spell out how such ascriptions might work, and so we are left with a sizable gap in his account of property attribution by reference to underlying atomic qualities.

Beyond the problems of a primary/secondary qualities distinction, another difficulty with such atomist accounts is *justifying* our characterizations of the more fundamental qualities we ascribe to atoms, given that any phenomena below the level of perceptibility is perforce unfamiliar. To arrive at such characterizations, we extrapolate

from experience with familiar phenomena of macro-sized objects and posit that something relevantly similar occurs on the microphysical level. However, there is no *prima facie* reason to accept such posits save that they are explanatorily felicitous—and this, too, is not certain. Dijksterhuis, for one, suggests Gassendi's atomist accounts of macro-phenomenal properties are not so much explanations at all as they are elucidations. His complaint is that, whether we explain macro-phenomenal properties by assigning the same properties to atoms or groups of atoms—or else suggest such properties arise from atomic motions and interactions—in any case we do not learn *how* or *why* it is that those micro-properties or phenomena should give rise to the phenomena we associate with macro-sized bodies.<sup>76</sup> There is, indeed, very little in Gassendi's account (or the accounts of other, more experiment-oriented seventeenth century corpuscularians, including Lémery and Boyle) which could be said to satisfy the need for such robust physical explanation. Yet there is explanatory content here, consisting in his account's chemically significant aspect—that it is the actions and combinations of a standard set of micro-structures, with a standard set of properties, which underlie macro-phenomenal qualities. Gassendi's own chemical observations, we will see below, are quite rudimentary but the intent of his programme is clear: what changes we can effect on the micro-level of matter should make consistent differences on macro-level phenomena. If we take such a method of difference to yield viable explanation, then his account (like other such accounts based in part or whole on a primary/secondary qualities distinction) provides more than simple elucidation. It remains a further question, of course, as to whether what is simply *viable*, and not necessarily *validated*, explanation warrants his extrapolating from familiar phenomena to begin with.

Whether or not these are merely viable or well-warranted explanations, one further problem is that these are apparently no more than qualitative microphysical accounts. That is a disappointing result for the early modern project of mathematizing the sciences. However, this was not a project in which Gassendi was particularly interested. Indeed, even if he had wanted a quantitative account, it has been suggested, he could not have one. Thus Dijksterhuis argues that Gassendi's account could not be quantitative given that the account

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<sup>76</sup> Dijksterhuis (1961), 430.



ranges over a vast variety of corpuscular shapes.<sup>77</sup> It is not impossible in principle, though, for such an account to be quantitative and range over diverse phenomena and entities. It would simply have to feature the sort of internal heterogeneity we find in, for example, biomechanics, rather than featuring the homogeneity we find in the most general physical mechanics. Gassendi offers his atomism as the basis of an internally homogeneous physics, though, and so the heterogeneity which marks his account of the micro-world is, in the end, an untidy, multifarious basis for constructing objects of the macro-world. None of this, however, yields Dijksterhuis's stronger claim that it is so excessively unwieldy a picture as to not possibly bear quantification. More significantly, in his ambition to develop an integrated account of all motion Gassendi attempts (in a different way) to make his physics a homogeneous affair yet falls short, given what amounts to a perplexing set of views about the motion of atoms and their aggregates. This, along with the more basic issues concerning locating causality among the atoms, is the topic I address next.

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<sup>77</sup> Dijksterhuis (1961, 430) suggests that the infinitely diverse varieties of micro-sized bodies that Gassendi's matter theory entails proscribes any appeal to formal systematization or quantification ('mathematical treatment'), which in turn blocks any experimental 'verification' of that theory. It is not clear, though, why such diversity prevents his atomism from being systematizable or quantifiable, much less being verifiable.



## CHAPTER TEN

### ATOMIC MOTION, CAUSAL ROLE, AND INTERNAL IMPETUS

The motion of atoms, according to Gassendi, is internally and efficiently caused by an impetus or inclination to mobility.<sup>1</sup> Thus there is no direct immaterial cause of motion in atoms. Rather, when God imputes to atoms such an inclination along with all their other fundamental qualities, his action is an *indirect* immaterial cause of everyday instances of atomic motion.<sup>2</sup> Sometimes Gassendi refers to this inclination of atoms to motion as a force (*vis*) and other times he refers to it as weight (*pondus*) or heaviness (*gravitas*). This weight is not only, or perhaps not at all, one of the measurable characteristics of atoms (as size or shape);<sup>3</sup> it is instead a kind of internal impulse,

... a natural, internal faculty or ‘force’ [*vis*] by which an atom can move of its own self; or, rather, it is an in-born [*ingenita*], innate, native, and ineliminable [*inamissibilis*] inclination to motion, a propulsion and impetus from within.<sup>4</sup>

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<sup>1</sup> What is motion for Gassendi? He follows Epicurus in suggesting that it is the passage of a body from one place to another. One reason for adopting the Epicurean account, Gassendi suggests (*O I 338*), is the promise of a simple and intuitive alternative to Aristotle’s murky definition, according to which motion is “the actuality of the potentially existing qua existing potentially” (*Physics*  $\Gamma$  1, 201a11–12). Yet the Epicurean account is not without limitations, for it binds one’s physics to talk about local motion alone. Gassendi, for his part, does not think this is a problem, almost certainly because he thinks that by drawing on the right kind of corpuscular story we can account for *all* motion as local.

Gassendi’s simple conception of motion is clearly not our own modern notion—his conception addresses neither a trajectory of motion nor the instantaneous velocity of a moving body in every instant of motion; q.v. Richard T.W. Arthur, “On the Premodern Theory of Motion: Galileo and Descartes”, unpublished manuscript (2004). Remarkably, both ideas, at least in germinal form, nevertheless feature in Gassendi’s fuller understanding of motion. Yet while his treatment of the former idea is markedly inertial, his treatment of the latter is not, generating a series of problems, as I note below.

<sup>2</sup> *O I 280b*.

<sup>3</sup> *O I 273b*.

<sup>4</sup> *O I 273b*.

By proposing this ‘internal faculty’, Gassendi locates the source of all causal agency among material objects in the atoms which constitute them—and in his extensive review of theories of natural causation from Epicurus to Kepler, Gassendi develops his own view as to what such location implies. Notably, his view of agency in atoms should explain what causes physical events, all the while avoiding the untoward extremes of an atheistic atomism on the one hand and the gratuitous involvement of God in everyday affairs of the universe on the other. Whether entertaining theories of light or magnetic attraction or the generation of organisms, he looks for a common causal story that underlies all natural phenomena and does not require the finger of God in all events—though neither does it exclude God’s role altogether. By locating physical causal agency in atoms, Gassendi allows that causation in nature can be explained by reference to states and interactions of matter’s constituent particles alone, without having to appeal to divine agency in our causal picture at any stage past Creation.<sup>5</sup> When the question arises as to how atoms came to have that agency, it is perfectly consistent to suggest, as Gassendi does, that God the creator must have made atoms in just that way.<sup>6</sup> God remains, theologically speaking, the ultimate causal agent—the First cause *per se*. Yet atoms, which constitute “everything in nature except God, that has some capacity to act”,<sup>7</sup> are the proximate causal agents behind all instances of physical motion:

... the first moving cause in physical things is atoms; while they move through themselves and through the force which is continually received from the Author from the beginning, they give motion to all things. And therefore, these atoms are the origin, principal, and cause of all motions that are in nature.<sup>8</sup>

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<sup>5</sup> Gassendi writes: “Motive force, which in whatever way is in a concrete thing, owes its origin to atoms.” *O I* 384b; see also *O I* 343b, *O I* 638a. Antonia LoLordo (2005b) notes that, in limiting God’s role to the original installation of *vis motrix* in atoms, Gassendi stipulates a place for divine creation that exceeds what one finds in the Epicurean account (avoiding any charges of atheism against atomism) yet allows for secondary causation. Such causation, she points out, in turn does not necessitate the assent of God for atomic motion, contrary to the suggestion by Margaret Osler (1994) that this is what is required of matter given its inert quality.

<sup>6</sup> For Epicurus, there is no need for a creation story because he thinks the atoms have been around forever, with all of their basic properties. But for Gassendi, at the very least his theological interests suggest that nothing *else*—for example, no other bodies—could have made atoms and invested them with a tendency to motion.

<sup>7</sup> *O I* 333a; *B* 409.

<sup>8</sup> *O I* 337a; *B* 421.

Indeed, atoms serve as the ‘engines’ of *all* material change—including psychological drives—which suggests to Gassendi a more colorful metaphor, the ‘flower of matter’:

When a child rushes towards a fruit which is shown to him, it is not only the metaphorical motion by which the fruit tempts him that is necessary, it is still and above all the physical or natural force which exists in this child and which directs and pushes him towards the fruit. This is why, for each thing, since the principle of action and movement is the most mobile and active part—in some way the flower of all matter [*quasi flos totius materiae*]<sup>9</sup>—and the part which we are accustomed to calling form and which we can conceive of as a very loose arrangement of very subtle and mobile atoms, it seems more natural to say that the first cause of motion in physical things are atoms. This is because, while they move themselves in virtue of the force they have received from their Author from the beginning, they give motion to all things and are consequently the origin, principle, and cause of all movements that exist in nature.<sup>9</sup>

In brief, this internal principle of motion found in all fundamental particles is what entitles us to think of them as causal agents.<sup>10</sup> It follows that causal relations between bodies are the product of phenomena internal to those bodies, and in this Gassendi avoids two unsatisfactory alternatives. The first is that we base our causal principles on the premise that agency is somehow located *externally* to the causal relations we seek to explain, as in some theologically-inspired views or the proposals of neoplatonists or Kepler (a Pythagorean of sorts) who see causal efficacy in incorporeal sources such as the harmonies of the spheres.

Yet we need to locate efficient causation in something corporeal, Gassendi argues, because all actions of bodies are physical, and physical actions may be brought about only by corporeal principles.<sup>11</sup> Among the incorporeal alternatives he rejects are those theories that suggest a source of physical action in a ‘soul of the world’ which,

<sup>9</sup> O I 337a; B 421.

<sup>10</sup> O I 333a; B 409.

<sup>11</sup> O I 335a–b; B 415–416. Gassendi charges that the Aristotelian alternative, that *form* is an incorporeal principle of motion, is incoherent since it is not possible to conceive of form completely bereft of matter. Further, he contends, even if it was possible, form would either be a merely passive mode of matter and so incapable of making matter active, or else an additional entity the origin of which would be a mystery.

according to some versions, is God.<sup>12</sup> One version of this view has it that a soul of the world produces a vital heat as the source of action—which Gassendi rejects as unrepresentative of any viable world-soul perspective given that heat is corporeal. In general, though, any such perspective that says God is the causally efficacious soul of the world introduces superfluity to our physics because we do not need God's actual presence in matter to account for the action of bodies:

It is sufficient that God be incorporeal and that he pervade and support the universal machine of the world, but it is not necessary for him to be like the soul, or the form, of the world in such a way that his substance is pulled apart . . . and cut into little pieces which become the individual souls . . . of men, but also of beasts, even of plants, even of metals, of stones, and of every single thing. . . .<sup>13</sup>

Moreover, Gassendi proposes, it is absurd to suggest *anything* incorporeal could be divided into parts or affected by anything corporeal.<sup>14</sup>

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<sup>12</sup> As Brundell (1987, 126–132) and LoLordo (2005b) suggest, the ‘soul of the world’ hypothesis with which Gassendi is concerned is endorsed by a wide range of Renaissance and early modern authors, from eclectic thinkers—including Yehuda ben Isaac Abravanel (Leone Ebreo), Paracelsus, and Robert Fludd—to more traditional philosophers—including Campanella (*De Sensu Rerum et Magia*), Agrippa, Telesio, and Patrizi (who promoted an overtly panpsychist view). Earlier, William of Conches (whom Gassendi read closely) developed an influential pre-Renaissance antiquarian defense of the *anima mundi* (q.v. Tullio Gregory, *Anima Mundi: La Filosofia di Guglielmo di Conches e la Scuola di Chartres* (Florence: G.C. Sansoni, 1955)) but the defense best known in the early modern era (clearly marking the views of Fludd, Abravanel, and others) was that offered by Marsilio Ficino (q.v. *Platonic Theology* (*Theologia Platonica* (1474), ed. James Hankins with William Bowen; trans. Michael J.B. Allen & John Warden (Cambridge, MA: Harvard University Press, 2001–2003)). The history of *anima mundi* theories dates back to the presocratics, though the earliest perspicuous statement is offered by Plato in the *Timaeus* (35A). Indeed, the strongest *anima mundi* currents run through neo-platonism, as captured in Gassendi's pocket history of such theories, from Plato through Cicero, Virgil, Plutarch, and Plotinus; q.v. *O I* 155a–162a. Some construe the Stoic *pneuma* theory as a related, or at least sympathetic, view given its suggestion of a structural principle that infuses all the world and is spiritually sustained; Gassendi's discussion of this view, we will see, is focused on the physical, rather than spiritual, character of *pneuma*.

<sup>13</sup> *O I* 334a; *B* 412.

<sup>14</sup> *O I* 334b; *B* 413. The specific target of Gassendi's criticism here is the notion that the *anima mundi* inheres in everything. On a most basic theological plane, this appears to suggest pantheism. Further metaphysical puzzles stem from the possibility that the deity may be instantiated as an extended thing. In particular, one of Gassendi's worries is that physical division of an amalgam *anima mundi* might be required to guarantee the individuality of constituent souls. As LoLordo notes (2005b), one need not assume this; the *anima mundi* theorists generally held instead an

Even more radical in this regard are those views suggesting that some objects might be causally related though they never actually interact. The early Kepler, for one, offers the neo-Pythagorean claim that numerical relations determine the order of the cosmos.<sup>15</sup> Robert Fludd proposes the Rosicrucian view that the world is causally governed by sympathies and antipathies resulting from a mixture of lightness and darkness, which characterizes all things.<sup>16</sup> Gassendi's

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'emanation' relation between the world-soul and constituent souls. All the same, the possibility of *any* sort of divisibility concerns Gassendi, for it leaves open the prospect that all constituent souls may be theologically undifferentiated parts of the world-soul, which presumes too little discrimination among souls of distinctive sorts of things (O I 334b).

The further worry which Gassendi expresses here concerns causal relations between the corporeal and incorporeal: there should not be any. God produces physical events not by his own motion but by his mere command, and incorporeal souls stimulate only incorporeal acts (like mental acts). The capacity of angels for moving matter is a more vexing problem, for which Gassendi sees only recourse to theological explanation. LoLordo suggests (2005b) that, by ruling out points of contact of souls with material bodies and concluding that there is no causal influence, Gassendi might be seen to be begging the question regarding contact action. Yet, as she notes, one could parse Gassendi's complaint as the notion that *at least some* causation is by contact action—which she thinks less controversial than positing universal contact action. Then *anima mundi* theory fails because it claims that *all* causation is through the action of immaterial emanation. There are two problems here: One, it is not any less controversial a claim for the *anima mundi* theorists, if indeed they reserve all causation for the world-soul. Two, if they do not reserve all causation accordingly, then allowing that some causation is by contact action does not rule out the world-soul as the most significant causal factor, as per the early Keplerian view.

<sup>15</sup> O I 634a. Gassendi accepts the Keplerian account of the basic mechanism of the motion of celestial bodies, by 'fibers' that push and pull one body by the motion of another. What makes the mechanism work, though, is quite different on the two accounts. Kepler (at least in his earlier, more mystically-oriented writings) holds that a world-soul is causally responsible. Gassendi, while allowing that talk of a soul is not inappropriate if reference to God is intended, insists on a mechanical underpinning to the fibers that set the bodies in motion. Kepler himself, while not proposing that these fibers were physical entities, accepted that they behaved in analogous ways, similarly to light and almost identically to magnetism. Indeed, Martens refers to them as 'magnetic fibers'; q.v. Martens (2000), 81–84; Kepler (1609 [1992]), 381, 390–391.

<sup>16</sup> Q.v. Robert Fludd, *Clavis Philosophiae et Alchymiae Fluddanae. Sive Rob. Fluddi, ad Epistolam Petri Gassendi Exercitationem Responsum* (Frankfort: William Fitzer, 1633), and Gassendi's 1630 treatise on Fludd, *Examen Philosophiae Roberti Fluddi Medici* (O III 213–270). Fludd's view is that the world-soul inheres in all of Creation, establishing a universal harmony that constitutes the source of events in the world—this extends even and especially to musical phenomena; q.v. Peter J. Ammann, "The Musical Theory and Philosophy of Robert Fludd", *Journal of the Warburg and Courtauld Institute* 30 (1967), 198–227. Thus causation is a function of order and structure. For Fludd, the *anima mundi* consists in an "essential light" (*lux essentifica*, q.v. *Utriusque*

mechanistic physics leaves no room for such claims—though neither do his cosmological and psychological accounts, which appeal to a panorama of causally-active spirits. These accounts stipulate causal relations between objects only if they interact physically, mentally, or—as his psychology has it—as a hybrid of the two. At all events, interaction of one sort or another among  $n + 1$  entities is a requisite element of the causation story. Neo-Pythagoreanism, neoplatonism, and Rosicrucianism (insofar as it constitutes a coherent doctrine altogether) by contrast require no such interaction, appealing instead to putative causally efficacious features of the universe such as numeric analogies, geometric patterns, or—as promulgated by Fludd—forces of an as yet more mysterious character. Gassendi's entire natural philosophy and theology militate against such an interaction-free model of causation—and relative to his account of atoms in particular, he holds that all apparent physical action-at-a-distance can be explained in terms of contact action (see chapters 11 and 12).

A second alternative is that, following the Aristotelians, causal efficacy consists in *internal* features or 'principles'—namely, substantial form—that are necessary to and definitive of, though not physically present in, bodies of a given kind.<sup>17</sup> Gassendi rejects this view on the grounds that not all that is definitive of bodies of a given kind is necessarily causally efficacious, and is even less likely to be so if one cannot physically locate the supposed agent.<sup>18</sup> This Aristotelian

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*cosmi majoris scilicet et minoris metaphysica, physica atque technica historia* (Oppenheim: Johann Theodor de Bry, 1617–1619), 79; Ammann (1967), 201) or, in a more theological vein, the Christ figure (*The Mosaicall Philosophy* (London: Humphrey Mosely, 1659), 29; LoLordo (2005b)).

<sup>17</sup> In this context, Gassendi is not concerned to take on the entire Aristotelian theory of four causes, which turns out to be more complex than he suggests. On the late scholastic four-cause scheme outlined by Suárez—to take one example—the causally efficacious is not always internal to those bodies bearing causal relations. For Suárez, causes may be 'intrinsic' (material and formal) or 'extrinsic' (efficient and final) (q.v. *Disp* 15 §9 ¶ 6, *Opera* 25, 534, and Des Chene (1996), 128). Gassendi neglects the 'extrinsic' causes, focusing on *substantial form*—that which individuates and is always joined with matter—as cause. Substantial form is a more natural target for him, as it is understood by a number of late Aristotelians to be causally responsible for all other forms, and thereby the unique causal principle underlying all of a given thing's active powers (q.v. Des Chene (1996), 66–74). As the sort of form that is always unified with matter, substantial form may also be the element of the Aristotelian scheme that is most plausible from Gassendi's materialist causal perspective.

<sup>18</sup> *O* I 335a; *B* 415. Gassendi also takes the Aristotelians to suppose that substantial forms, as the active aspect of substances, constitute some kind of incorporeal



approach only looks viable, he maintains, if we suppose that causal principles may be distinct from matter. By that standard, attributing to one substance the ability to bring about action affecting *another* substance in virtue of their material character looks like a confusion of material and efficient cause.<sup>19</sup> But this supposition is made without justification, Gassendi contends. Thus, in response to Aristotle's charge that the early atomists do not even attempt an account of the cause or principle of motion, Gassendi proposes that Leucippus and Democritus simply make internal to atoms what Aristotle mistakenly takes for granted as a separate, extra-material causal principle. The ancient atomists, Gassendi suggests,

. . . only wanted to ensure that the efficient principle not be considered distinct in substance from the material principle. It is to be noted...that they considered atoms not to be inert and immobile at all, but on the contrary to be extremely active and mobile. And for this reason they held them to be the first principle of motion. However, Epicurus expressed the doctrine more explicitly when he said that the property of atoms which Democritus did not name was in fact their weight, the source of their motion.<sup>20</sup>

Elsewhere, Gassendi plainly equates causation *simpliciter* and efficient causation, though he also appears to distinguish final causation as a viable kind, relative to generation and other phenomena.<sup>21</sup>

An element of this second alternative also shows up in the otherwise rather distinctive view of the Stoics. For while they hold that causal principles of the physical realm are corporeal—indeed, the Stoics propose that there are no causes that are not bodies—like the Aristotelians they also fail to tie causal efficacy to particular bits of

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causal agents, which he accordingly dismisses on the grounds (discussed above) that there can be no such agency among material objects altogether. Worse still for the Aristotelians, he argues, forms cannot be active as they are supposed, because they are mere aspects or modes of entities and not themselves distinct entities (LoLordo (2005b) notes that Gassendi is addressing here a typical Aristotelian view of the time, associated with Sennert and Scipion du Pleix). But if the forms cannot be active, then they cannot be causal agents.

<sup>19</sup> Aristotle levels this criticism against pre-Socratics like Heraclitus but, as Gassendi notes, atomists are also subject to this charge, for they maintain that these two Aristotelian causes are actually (if not conceptually) indistinguishable as the primary principles of matter; *O* I 333b–334a; *B* 411.

<sup>20</sup> *O* I 333b; *B* 410.

<sup>21</sup> On the equation of causation and efficient causation, q.v. *O* I 283a; and LoLordo (2005b); on generation and final cause, q.v. chapter eleven.

matter. There are no discrete parts of matter to which one may attach causes given that all matter is of a continuum. Moreover, all causality is of a continuum: all present events are causally determined by the totality of all past events. The Stoics locate this extraordinarily robust causal principle in the *pneuma*, the active spirit or force that pervades all matter and acts as the efficient cause of all events.<sup>22</sup> Gassendi does not actually object to their physics on these grounds. Instead, he praises the Stoics for their attribution of cause to body<sup>23</sup> yet criticizes them for distinguishing two types of substance (matter and *pneuma*) and attributing efficient causality to the latter only.<sup>24</sup> Nonetheless, the Stoic picture of physical causation most dramatically conflicts with Gassendi's picture relative to *where* the causal agency is found. The concept of a globally dispersed agency in the form of an all-pervasive force is wholly foreign to Gassendi's physics.

By locating causal agency in atoms—specifically, maintaining that atomic weight makes them essentially mobile—Gassendi hopes to offer a more plausible story of natural causation than the available alternatives. Unlike those other perspectives, his story is consistent with the view that such agency is internal to bodies and defined independently of any other, non-physical features thought to be characteristic of bodies.<sup>25</sup> His root assumption is that underlying causal

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<sup>22</sup> Gassendi refers to the *pneuma* as 'animal' or 'vital' spirit; q.v. *O I* 333b; *B* 410. The Stoics also conceive of *pneuma* as the 'sustaining cause' (*synektikon aition*) that gives all bodies their individual qualities—akin to the Aristotelian formal cause. Q.v. S. Sambursky, *Physics of the Stoics* (Princeton, NJ: Princeton University Press, 1959); Dirk Baltzly, "Stoicism" (2004), in Zalta (1995–), <http://plato.stanford.edu/entries/stoicism/>.

<sup>23</sup> *O I* 333b; *B* 410.

<sup>24</sup> Gassendi claims that, whereas his active atoms wed matter and efficient cause (per Epicurus), the Stoics distinguish matter from active *pneuma* and so separate out efficient cause; q.v. *O I* 333b; *B* 410. Yet this is not clearly a fair charge on Gassendi's part. Taking *pneuma* as a force pervading matter, it seems a causal principle no more distinct from matter than *pondus* is from Gassendi's atoms. In this vein, Brundell suggests that Gassendi allowed that Epicurus followed the Stoic view of attributing innate activity to all matter (1987, 122). If so, it is not clear why Gassendi describes the Stoics as having a radically different view of matter's general relation to efficient cause than his own.

<sup>25</sup> LoLordo (2005b) notes that, in a separate discussion, Gassendi considers further competing theories of the sources of causation, all of which also locate the font of causal activity within bodies—in their elemental or secondary qualities. One group of such theories identifies the elemental qualities of fire, air, water, and earth (per Hippocrates and Thales)—or in an alternative form, hot, cold, wet, and dry—as causally active; q.v. *O I* 241b. Another group of such theories focuses on canonical sets of secondary qualities proposed by the 'chemists'—notably, the Paracelsan

relations among physical objects—which we standardly take as evidence of some sort of agency—are causal features innate to those objects so related. If this were not so, such relations might fail to pick out any particular sort of causal agency among the relata or even indicate that the agency is located among the relata altogether. Yet Gassendi suggests, the causal relations among physical objects tell us precisely what sort of agency these must be: given that the actions of bodies are corporeal, the causal principles that bring those actions about must be corporeal, too. Anything that compels one body to move must itself be a body—either the same body, in the case of internally-generated motion, or another body, in the case of externally-generated motion (e.g. by contact action).<sup>26</sup> On the basis of this root assumption—together with his further claims that all that exists is matter and void and that matter is the primary bearer of physical causal relations—Gassendi is able to locate the principal causal feature, weight, in what he takes to be the basic unit of matter, the atom. In sum, he proposes that atoms have inherent motion—

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*tia prima* and Helmontian five elements; q.v. *O I* 241b, 244b. A third group of such theories highlights various other sets of secondary qualities, including heat and cold (Telesio and Campanella), heat and light (Patrizi), and rarity, density, and levity (Digby); q.v. *O I* 245b. Yet as LoLordo stresses, Gassendi views these various theories as accounts not of the general and originary activity of matter but of particular, quality-specific, and secondary activities. To explain the underlying and central source of all activity in matter, he proposes, one must appeal to the ultimate and shared nature of all bodies, which is atomic in character; q.v. *O* 245a. What makes all bodies active, whatever other qualities they may have (including those related to activity), is the *vis motrix* of their constituent atoms. As LoLordo points out, this account directly addresses the relationship of activity to motion, unlike the accounts centered on elemental and secondary qualities. The question remains, as we see below, how or why the active principle contributes to motion.

<sup>26</sup> It is not the case, however, that this view requires that causality be located in—rather than among—bodies. That whatever moves a body must itself be a body is a physical principle perfectly consonant with a metaphysical commitment to causality as located either in the incorporeal or among the corporeal. The problem in Gassendi's reliance on this notion is that attributing or proscribing motion to or actions among types of things does not entail attribution or proscriptions of causality among those types of things. Indeed, Gassendi recognizes something of this, noting that God acts "... by mere command, for he is ubiquitous and infinite in power." *O I* 334b; *B* 413.

As for the soul, Gassendi falls back on a tripartite division that allows the incorporeal parts to feature incorporeal action, and corporeal parts to feature corporeal action. Relative to angels and demons, who are supposed to be incorporeal yet are thought to interact causally with bodies, Gassendi takes recourse in the possibility that theology may be explanatorily relevant where reason cannot be (*O I* 335a; *B* 415).

a *vis motrix*—and he defends that notion on the grounds that just such an atomic feature yields our best understanding of how causal relations arise out of the features of individual material relata.<sup>27</sup>

It may be asked whether, having located causal agency in atoms, Gassendi intends that location to be exclusive. That would be one reasonable reading of his notion that efficient causation must be corporeal. Further, in his resulting account of causality we have seen that he lands on inherent motion of atoms as the single best alternative to the range of other views he considers. Yet nothing in that account explicitly rules out other modalities of efficient causation among bodies, such as those entailing the impressed force of one body against another. There may be excellent reasons, we will see below, to *not* admit any further efficient cause, and in much of his discussion of atoms Gassendi tries to hew to this line. We shall also see, however, that Gassendi's other physical commitments—most notably his principle of inertia—suggest good reasons to allow for a causal agency which is external to bodies. A difficulty in navigating these competing possibilities is that Gassendi is not entirely thorough on such matters. While focusing on the inherent *vis motrix* of atoms, for example, he never states outright that no one atom can impart motion to another.

At all events, to conclusively demonstrate that atoms having inherent motion provides our best understanding of causal relations, Gassendi sets out to defeat the principal argument *against* that view. This greatest threat he identifies as the argument that we can take nothing—including matter in any form—to be the source of its own agency, or else we risk conflating artisan and artifact.<sup>28</sup> To this he

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<sup>27</sup> LoLordo suggests (2005b) that the mere ascription of qualities (such as weight or the related *vis motrix*) to bodies should render them active, given that Gassendi thinks of qualities as powers, hence efficient causes. Yet as we saw in chapter nine, aside from *vis motrix*, the primary qualities of bodies (those we associate with atoms) do not have powers to bring about some other phenomena. Thus, shape does not yield some specific phenomenon the way *vis motrix* yields motion. And the secondary qualities he describes—including heat, color, cohesion, and special forces like magnetism—are identified not as powers or capacities in themselves. Rather, they are qualities that are brought into existence by the aggregations, relations, and interactions of different atoms or their properties, or even the context of their containing bodies. Further, Gassendi offers no reason to think that the contrary view holds, that is, that matter with no qualities—such as the Aristotelians think possible—on those grounds would be inert.

<sup>28</sup> This is a charge that dates to Aristotle, who complains that the same thing would be in act (as the mover) and in potential (as the moved, or passive, body);

responds that while artifacts are by definition endowed with agency by distinct agents (namely, their creators), there is no appropriate analogy with small natural bodies that compose the structure of larger natural bodies and contribute their agency to those encompassing structures. This is because the smaller bodies are not the intention-endowed creators of the larger bodies. Hence the motion of the encompassing structures may depend solely on the agency of their internal components whereas inanimate artifacts depend on agency from without. A more appropriate analogue to natural (non-artifactual) aggregate bodies, Gassendi suggests, is found in an animated artifact—a social grouping like a military unit that functions as a whole because of the agency of its internal components. In such cases there is no trouble reducing the corporate agency to the sort of individual agency God builds into the elements of the corporate whole, and so it is with the elements of matter.<sup>29</sup> In short, this argument against the inherent motion of atoms is based on an analogy between natural things and artifacts that is simply mistaken, for it assumes that the former must be inert.<sup>30</sup>

Yet Gassendi's refutation can be none too compelling for such opponents of inherent atomic motion. They are not as worried about whether larger bodies composed of atoms may get their motion (from their constituent parts or otherwise) as they are about where atoms themselves get (or sustain) their own motion. But even if the refutation were compelling, other problems remain. For one, Gassendi's proposal may be considered to yield a species of 'vitalism' given his suggestion of an inherent motive force in atoms that is a necessary and sufficient condition for the activity of living things.<sup>31</sup> This is

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q.v. *Physics* VIII vi, v 257b; and *Metaphysics* XII vi 1071b. The theologically minded critic may refashion the problem as conflating the Creator and Creation.

<sup>29</sup> *O* I 336b; *B* 419.

<sup>30</sup> *O* I 336a; *B* 418–419. He adds that, if we now work our way back through the proposed analogy with artifacts, and we *did* assign internal agency to their parts, we would be stuck with the absurd result that they are all automata.

<sup>31</sup> 'Vitalism' is the modern term—associated with the nineteenth century *naturphilosophie* for the attribution of living qualities to nonliving matter. In seventeenth-century terms, we might less anachronistically think of such views as belonging to a family of doctrines of living matter, where spirit may play a role (or not). These views can be grouped as a sort of 'animism', per Mary Hesse (1960), 42, 132)—though only with the understanding that, *contra* Hesse's sense, for some figures (including Gassendi, as we see below), living qualities arise in purely material circumstances.

akin to the sort of active force we find in Leibniz's monads—or, perhaps more analogously—the derived *vis viva* that his secondary matter features. Like Leibniz after him, Gassendi tells a quasi- (and proto-) vitalist story about the workings of those corpuscles from which all organisms and at least some aspects of mental apparatuses are built.<sup>32</sup> Some atoms are designated in the moment of Creation, to come together and form 'seeds' (*semina*). Such 'seeds' are a common building block for all manner of what we view as organic and non-organic structures; for Gassendi, that distinction was less well-defined as he put animals on one end of a continuum with geological formations on the other. These 'seeds' carry developmental information for animals and plants, and structural and compositional information for crystals, metals, and minerals.<sup>33</sup> This is not a full-blown vitalism or animism, for although qualities of living things are attributed to things we do not take to be living (whether in the *vis motrix* of atoms or the seminal properties of rocks), all such qualities

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<sup>32</sup> Leibnizian individual substances—monads—also are active yet follow causal laws. And, as one might suppose of elemental individuals endowed with their own internal motion, they do not communicate motion among themselves (as we see below, though, this contrasts with Gassendi's atoms, which he somehow expects to transfer and add motion, one to the next). In further contrast to Gassendi's atoms, Leibniz's monads contain—through their complete individual concept—all their own motions and relations (hence *apparent* interactions) *ad infinitum*.

Occasionalism also suggests that there is no transfer of motion among bodies. However, occasionalists take a significant further step, jettisoning real secondary causes by rejecting all possibility of bodies moving themselves, setting themselves in motion, or—lacking force—moving other bodies (q.v. Nicolas de Malebranche, *De la Recherche de la Vérité. Où l'on traite de la nature de l'esprit de l'homme, & de l'usage qu'il en doit faire pour éviter l'erreur dans les sciences* (Paris: André Pralard, 1674), VI 2.3).

<sup>33</sup> Q.v. Hiroshi Hirai, "Le Concept de 'Semence' dans les Théories de la Matière à la Renaissance, de Marsile Ficin à Pierre Gassendi" (Ph. D. diss., Université de Lille III, 1999) and Norma E. Emerton, *Scientific Reinterpretation of Form* (Ithaca, NY: Cornell University Press, 1984). Gassendi does not limit discussion of atoms as parts of systematic wholes to his accounts of *semina* (plants (*O* II 169–179), animals (*O* II 267–272), crystals (*O* I 271a), and minerals (*O* II 114a)). Even the heavenly bodies are composed of atoms the motions of which contribute to the larger bodies (*O* I 638b–639a). The revolution of heavenly bodies around an external central point results from the dragging action of rays or chains from the body at the central point (namely, the Sun or Earth, depending on the degree of one's Copernicanism). Rotational motion around a given heavenly body's axis is inertial, as Messeri notes (1986, 100), at least as concerns its rectilinearity (defined along the circuit) and indefinite continuity of motion given that it is not being halted. It is not a perpetuation of impressed force on a point outside the planet's center but instead generated by the *vis motrix* of the body's constituent atoms. The atomic motions cannot drive the heavenly bodies in straight lines since they are constrained by being held together; accordingly, the bodies turn on their axes.

are for Gassendi subsumed under the material. The catch is that his matter is not inert—hence the charge that his physics, biology, and geology alike are all animist or proto-vitalist. Yet even if this view is not any sort of vitalism or animism *per se*, it may be poorly suited to a mechanist natural philosophy, rendering unclear how the sorts of things that feature their own internal motion (be they organic or not) could obey his general physical principles.

There are, it turns out, a variety of physical difficulties with the picture of anything being the source of its own agency (quite independent of Gassendi's concern with the artisan/artifact problem). Minimally, that picture makes a mystery out of his principles of motion and his notion of change in velocity and rest (q.v. discussion below). Moreover, as Brett notes, locating the source of motion in the atoms themselves renders irrelevant any notion of causality that involves a relation between two or more objects; as Gassendi retains such a notion, the question is therefore as to its being superfluous.<sup>34</sup> The difficulties multiply in careful consideration of the suggestion that motion is not essentially imparted to one body by other bodies, at least on the atomic level. If there is no such imparting of motion, what accounts for the apparent phenomena of the same (on the macro-level)? On the other hand, if motion really is imparted from one body to another, how is this possible? Gassendi addresses the second question by proposing that objects that are moved require the involvement of another, motion-imparting agent: “. . . the same thing cannot be both the mover and the object moved . . . whatever is moved is moved by something else. . . .”<sup>35</sup> In attempting to avoid an infinite regress in causal explanation, Gassendi borrows the Aristotelian concept of a primary mover, which role he vests in the atom.<sup>36</sup> At the same time, though, he commits himself

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<sup>34</sup> George S. Brett, *The Philosophy of Gassendi*, (London: Macmillan and Co., 1908), 58.

<sup>35</sup> *O I* 336a; *B* 419.

<sup>36</sup> Specifically, he argues that if something could not move itself but had to be moved by another thing, then the mover *A* would not be moved in the action of moving another thing *B* unless a third thing *C* moved *A*—even if *A* and *B* were joined such that moving *B* entails moving *A* (*O I* 337a; *B* 421–422). A natural rejoinder from the Aristotelian perspective is that the composite *AB* could only be moved if some external *C* moved it. Gassendi differs with the Aristotelians, though, in requiring not an *unmoved* primary mover but one with its own source of motion—that is, as endowed by God, from whom all motion originates. Aristotle and his adherents explain the origin of motion by a final cause (attraction to the unmoved

to the imparting of motion by one body to another—which is difficult to reconcile with the proposal that atomic motion requires no such communication.

A different problem with attributing internal causal agency alone to physical bodies is the challenge of licensing the traditional view that such agency is readily attributed to forces *external* to bodies causally related, to wit, impressed and attractive forces. Gassendi's view may be put thus: such cases of external causation can be explained as the product of internal causal events, because those forces we take to be external are secondary phenomenal qualities that arise out of the primary qualities—principally weight or motion—of their constituent atoms.<sup>37</sup> For example, impressed forces of macro-sized bodies are composed of the internally-based forces of the atoms those bodies comprise, taken in the aggregate. Further, magnetic force is an attraction that occurs when one body issues a corpuscular stream that brings another body towards it by a grabbing action of corpuscular protuberances resembling hooks. While this is Gassendi's considered treatment of the issue, enshrined in the *Syntagma* (*De Qualitatibus Rerum*, Section I, Book VI of the *Physica*), elsewhere in his corpus he also treats such external impetuses as fundamental—particularly in *De Motu* and *De Gravia Proportione*. Yet even assuming his approach was consistent and viable vis-à-vis macro-level phenomena (see chapter 11), nevertheless a problem remains, on the smaller scale. Just in case we cannot rule out that such impressed or attractive forces operate among corpuscles, it is not obvious what, if anything, at that micro-level is underpinning traditionally-conceived external causal events. The answer cannot be the internal impetus of *vis motrix*, or else there is a net surplus of forces at work. Gassendi, for his part, does not address this issue.

Perhaps the most puzzling aspect of the proposal that atoms have an internal principle of motion is whether atoms are supposed to be

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mover as a goal-state), which Gassendi rejects as an appeal to a 'metaphorical motion' instead of a true physical cause.

<sup>37</sup> The discussion of impressed and attractive forces as secondary qualities ranges over gravity and *levitas* (*O* I 388–394; esp. 392f), motive force (*vis motrix*) (*O* I 384–388), and the magnet (*O* I 345b–346a, 347–348, and *O* II 128a–135b). In *De Motu*, q.v. *O* III 478a–536b, *passim*.

That weight or motion is treated as a *property* or *quality* of atoms is problematic insofar as Gassendi treats motion on the macro-scale instead as a *state*, as Westfall has noted (1971, 103–104). I discuss the consequences of this confusion below.



in motion at all times, and if so, whether it is possible to account for atoms at rest or for those conditions under which atoms should be at rest. Regarding the first part of this puzzle, does Gassendi think of his principle of motion as a constant impetus, an ever-present and active force that compels atoms to move? This is suggested by his claim that

... there persists in things, in a constant manner, as much impetus as there was since the beginning.<sup>38</sup>

Or else does he think of this principle as a mere dispositional state, an ever-present capacity of atoms to participate in the causal nexus?

This last possibility amounts to the suggestion that the motive principle of atoms is no more than a capacity, such that they need not always be in motion. Since Gassendi holds that *pondus* or weight gives atoms an inherent force (*interna facultas seu vis*) necessary for motion, this capacity for motion would be pervasive (in all atoms) and permanent (for the duration of Creation).<sup>39</sup> It does not follow, however, that all atoms would have to be constantly in motion. Moreover, given that Gassendi does not explicitly state that this inherent force is sufficient for motion, it is possible that he does not take their motion to be ceaseless.

One benefit of this dispositional interpretation is that atoms should turn out to be causally inert bodies (that is, governed by a principle of inertia)—which is what he thinks macro-sized bodies are. Another benefit is that the suggestion that an atom might be at rest does not have to be explained away. On the other hand, Gassendi would then have something new to explain, namely, when and how such a capacity or tendency is realized (so that motion starts), or not (so that motion ceases). In any case, aside from his failure to stipulate that the motive force of atoms is sufficient as well as necessary for

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<sup>38</sup> O I 343b. Gassendi's talk of 'things' rather than atoms *per se* ("... *ideo dici posse iuxta ante supposita, tantum impetus perseverare constanter in rebus, quantum ab usque initio fuit.*") seems to suggest that this innate propulsion persists at a constant rate for atoms both taken individually and as they are joined together, in aggregate bodies. Yet that interpretation leaves us with the unfortunate result that familiar-sized objects have a constant impetus which, understood as an active force, strongly conflicts with experience. This could be taken as evidence for a dispositional interpretation of the constant impetus. More neutrally, we might simply suppose that Gassendi is speaking here of 'things' in a technical sense, to refer to atoms.

<sup>39</sup> O I 273b, following Epicurus; q.v. *SPE* 17.

their ceaseless motion, there is no real textual support for this suggestion. The closest Gassendi ever gets to this view is when he seems to suggest that the internal principle of motion is not what some Scholastics (like Jean Buridan and Nicholas of Oresme) think of as ‘impetus’:

... the idea that atoms have impetus, or the power to move themselves inherent in their nature, is to be rejected and also its consequence that they have motion by which they have been wandering and have been impelled every which way for all time.<sup>40</sup>

In this passage he claims atoms do *not* have the power to move on their own, ceaselessly or otherwise as “inherent in their nature”. One possible reading is that, quite contrary to the view of atoms as containing a principle of motion, Gassendi suggests atoms only move if they are impacted upon—that is, they lack an internal and constant motive force. Yet in the very next sentence he proposes that atoms indeed feature such a force:

It may then be admitted that atoms are mobile and active from the power of moving and acting which God instilled in them at their very creation, and which functions with his assent, for he compels all things just as he conserves all things.<sup>41</sup>

This instilled ‘power of moving and acting’ must be the sort of internal impetus he appears to dismiss a moment earlier. The key to understanding these passages lies in his suggestion that this power ‘functions with [God’s] assent’, and that this is so because God compels things in the same way he conserves things. God for Gassendi is the primary metaphysical cause, as Creator and sustainer, even if matter has its own internal principle of action. Thus if we take God’s compelling things to be the same as his causing motion, then the cited passage suggests that God conserves and compels after Creation without interfering directly in it, like the hands-off guarantor of the Clockmaker model. God’s assent to atomic motion is not divine intervention but divine concurrence.<sup>42</sup> The power atoms have to move

<sup>40</sup> *O I* 280a; *B* 399.

<sup>41</sup> *O I* 280a; *B* 399.

<sup>42</sup> Q.v. also *O I* 323b, and Bloch (1971) 350–362. As Garber *et al.* (1998, 580) note, Gassendi shares some element of the divine concurrence view with Descartes, though differs from the Cartesian perspective in proposing that atoms-as-sustained are active in themselves. Descartes, for his part, holds that corpuscles are inert and

is very much their own, though they are not the self-same source of that power—as the Scholastics might have said, had they been atomists.<sup>43</sup> Gassendi's apparent concern here is to block an inference from the claim that impetus is internal to bodies to the further claim that such impetus is *intrinsic* to bodies, in the sense that it need not have been implanted by anything or anyone else—such as God. In this passage, then, he is not dispelling the notion of an impetus internal to atoms but stressing that this impetus must be an artifact of Creation. Such impetus as an atomic feature is not a brute fact about the nature of atoms or the universe, contrary to an intuitive notion one might draw from the view of impetus as “inherent in their nature”. Nothing he says here (or elsewhere), then, suggests that internal impetus as an active motive force must be rejected in favor of a tendency to motion. Indeed, the reference here to atoms as ‘mobile and alive’ further suggests that he instead conceives of such motive force as a property of atoms that constantly compels them to a state of motion.

The stipulation that a constant impetus compels atoms to move and that atomic weight—which just is this impetus—is a fixed and ineliminable property has the consequence that atoms have a constant *degree* of mobility. For each atom, there is some set degree to which it is propelled by its impetus, which accounts for what Gassendi takes to be paramount features of atomic motion—its perpetuity and spontaneity. Further, this set degree of motion among atoms best explains variation in the mobility of the macro-sized objects they constitute.<sup>44</sup> He considers, by way of contrast, two alternative accounts

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require force (God) to be moved. As we have seen, Gassendi rejects the notion that such incorporeal entities as God can act on or produce action in corporeal entities. Endowed with extension alone, Cartesian matter lacks a source of causation; q.v. *O* III (*DM*) 305b; *R* 158; LoLordo (2005b). For Gassendi, such force as moves atoms is either internal (per his Epicurean view of atomic *vis*) or, as we see below, external (per his mechanism, which governs impacts among all bodies, including atoms).

<sup>43</sup> Indeed, for Suárez, a core feature of primary and secondary causation is the dependence of the latter on the former. As with Gassendi and Descartes, secondary causes require the ‘concurrence’ of the primary cause—God. Q.v. Francisco Suárez, *On Efficient Causality: Metaphysical Disputations 17, 18 and 19*, trans. Alfred Freddoso (New Haven: Yale University Press, 1994), 31; q.v. Helen Hattab, “The Problem of Secondary Causation in Descartes: A Response to Des Chene,” *Perspectives on Science* 8 (2000) 2, 93–118, esp. 94.

<sup>44</sup> *O* I 335b–336a; *B* 417–418.

of variation in the mobility of macro-sized objects. One is that individual atoms may vary across time in their mobility; another is that some atoms are wholly inert whereas others are mobile.<sup>45</sup> As regards the second proposal, Gassendi may have been thinking of the Stoics, who—though they were not atomists—proposed that some matter is inert and some is active, or its own efficient cause. However well these two alternative scenarios account for variation in the mobility of macro-sized objects, though, they fail to insure that atomic motion is perpetual and spontaneous. Neither scenario provides any guarantee that atoms meeting obstructions or restraints will be able to resume their activity once those hindrances to motion are removed. Gassendi therefore rejects both alternatives and embraces the view that all atoms are endowed with constant degrees of mobility.

In light of this constancy on the micro-level, Gassendi allows, it is not obvious how macro-sized objects they compose may vary in their mobility. He proposes that we need some fashion of corresponding variation on the micro-physical level, and proposes that a sort of variation in atomic motion arises from those states where—because of obstructions or restraints—the impetus of atoms is constrained. This is not exactly coming to a state of rest, Gassendi maintains. Rather, such atoms continue to move even when restrained, perhaps by spinning or vibrating.<sup>46</sup> In those collisions where one or more atoms blocks the path of another, he suggests, their motion is merely prevented in one direction such that they veer off in another; they neither lose nor gain speed. In the very moment of collision, atoms ‘pause’ though they do not rest *per se*—that is, they do not lose their inherent mobility. When the one set of atoms ceases to block other atoms, they all begin their trajectory-wise motion anew, at original speed. Thus their motion retains its spontaneity.<sup>47</sup> In sum,

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<sup>45</sup> *O* I 335b; *B* 417. Gassendi dismisses the Aristotelian view that, without the presence of form, *all* matter is essentially inert—noting that form (as immaterial by definition) cannot act as a physical cause of material motion, much less contribute to a variety in the motion of bodies.

<sup>46</sup> Correspondingly, those atoms set in motion have ‘freed’ impetus—but in no case does Gassendi want to say that atoms ever lose their impetus.

<sup>47</sup> One result of the proposal that directly after being constrained, atoms pick up their pre-collision velocity where they left off, is that acceleration and deceleration do not occur at the atomic level. While this facet of atomic movement fails to preserve inertial motion in Gassendi’s sense (see discussion below), it is consistent with at least one other characteristic Gassendi attributes to atoms; as Dijksterhuis has noted, if they are truly solid, then atoms cannot behave as elastic bodies.

while the impetus of atoms cannot be permanently or wholly diminished by collisions or combinations with other atoms, its effects can be temporarily and partly blocked. How such impetus can be halted on a temporary basis—or subsequently resumed—we are not told, and the charge of an *ad hoc* solution looms greatly. Assuming that it is plausible to suggest that atoms themselves may move perpetually yet with some vicissitudes, Gassendi thereby allows for variation in mobility among the larger bodies they compose—including larger bodies at rest.<sup>48</sup> The biggest puzzle about this proposal, however, is why Gassendi thought there was a problem here to begin with. Macro-physical objects may vary in their mobility just as long as their atoms exhibit *any* sort of variety in their motion—that is, across atoms and relative to, for example, direction or rate—whatever the constancy of their being able, or even compelled, to move.

Aside from such puzzles and problems, one apparent merit of Gassendi's imputing motion to atoms is that he thereby ties together his mechanics and atomism—a principal objective of his physics. For if the 'principle of motion' or impetus is internal to atoms, everything that is in motion is corporeal (and conversely, nothing that is not a body moves), and everything corporeal is composed of atoms, then the account of motion *just is* an account of bodies that move and, more particularly, their constituent moving atoms. In the range of views represented by the mechanical philosophy, Gassendi thereby shapes a distinctive solution to guaranteeing that physical explanations are mechanical, by attributing the source of continuing material motion to a feature of matter itself. Descartes hints at a similar strategy in his account of secondary causation, though his precise attribution of worldly causes lies in natural laws, not material bodies *per se*.<sup>49</sup> Indeed, commentators have variously interpreted this suggestion as incoherent, because laws cannot have powers—or else as a proxy for God's causal powers or a felicitous account of the way the world would be were material bodies to be endowed with such powers.<sup>50</sup> Newton, for his part, pursues a course parallel to Gassendi's

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<sup>48</sup> This last sort of case Gassendi believes is evident from such empirical data (borrowed from ancient sources, including Epicurus) as our observations of particles of dust moving around in rays of sun light, and particles moving around in vapor created from the compound of mercury, tin, and sublimate. *O I* 287 ff., following Epicurus; cf. *SPE* 18.

<sup>49</sup> *AT VIII A* §61–62.

<sup>50</sup> For the divine causal powers view, q.v. Gary Hatfield, "Force (God) in Descartes'

in this respect—and attains a similarly low level of success.<sup>51</sup> Such attempts to link matter theory and a theory of motion—whatever its ill-fated nature—remained a goal for at least one group among the mechanical philosophers—with Gassendi at the forefront of that group. By contrast, such a strategy is quite foreign to those earlier Aristotelians who identify motion as a category conceptually distinct from those objects which move. The strategy is discarded altogether by post-Newtonians such as Euler and Boscovitch who admit fundamental forces and action through a continuum, rather than account for all physical phenomena in terms of corpuscles in motion, alone—or at all.

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Physics”, *Studies in History and Philosophy of Science* 10 (1979), 113–140; for the counterfactual-style view, q.v. Garber (1992).

Some commentators suggest that Descartes is committed to real secondary causes in the form of bodily forces, on the grounds that forces are modes of bodies (Martial Gueroult, “The Metaphysics and Physics of Force in Descartes”, Stephen Gaukroger (ed.) *Descartes: Philosophy, Mathematics, and Physics* (Totowa, New Jersey: Barnes & Noble, 1980), 196–229; and Alan Gabbey (1980)) or else superadded by God to bodies, and reapportioned as ‘needed’ (q.v. Desmond M. Clarke, “The concept of Vis in Part III of the *Principia*”, Jean-Robert Armogathe & Giulia Belgioioso (eds.) *Descartes: Principia Philosophiae (1644–1994)* (Naples: Vivarium, 1996), 321–339). The Gueroult and Gabbey interpretations, however, are not consistent with the cartesian views that the modes of extension are derived from matter’s essence (and as such, unchanging), and the Clarke interpretation assigns secondary causation to the intermediary actions of God; q.v. Hattab (2000), 99–100).

Hattab contends that the cartesian laws of nature are indeed secondary causes that determine the character and attribution of forces. In this view, she suggests, Descartes follows a Scholastic tradition of not considering secondary causes as forces causing effects (108; q.v. Francisco Toledo, *Commentaria una cum quaestionibus in octo libros Aristotelis de Physica Auscultatione* (Venice: Bernardo Giunta, 1573/1586; Cologne: Officina Birckmannica, 1574/1585), 60–61; Antonio Rubio, *Commentarii in octo libros Aristotelis de Physico auditu una cum dubiis & quaestionibus hac tempestate agitari solitus* (Madrid: Luis Sanchez, 1605; Lyon: Johannes Pillehotte, 1611), 262; and Suárez (1994), 39); thus, he does not attribute secondary causation to God. Instead, Hattab maintains, the laws play for Descartes the same role that substantial form plays for the Scholastics, determining the species of God’s concurring action (111). On this interpretation, the laws of nature ensure that only certain sorts of motion occur, as in bodily collisions, yet God’s actions by themselves are not constrained. This suggests two conflicting pictures of God, however—one where the effects of divine actions are constrained by the laws of nature, and one where any divine actions are possible. Moreover, those constraints are a product of God’s own immutability, and when Hattab insists that the laws of nature—rather than constituting God’s self-governance—simply ‘capture’ how God acts on matter (115), she reverts to the notion that God is the source of secondary causation.

Gassendi, for his part, diminishes any such complications by assigning all secondary causation to matter.

<sup>51</sup> Q.v. Ernan McMullin, *Newton on Matter and Activity* (Notre Dame: University of Notre Dame Press, 1978).

However valiant the attempt to guarantee the mechanical nature of physical explanation, tying mechanics to atomism in this way is only *apparently* advantageous. In the end, Gassendi's proposal of an innate atomic motion fits poorly with critical mechanist claims which he either states outright or transparently assumes. These include the claims that the differing primary material features of bodies should produce variable rates of motion, a principle of conservation of momentum, and a principle of inertia. That Gassendi's views on atomic motion fail to match up neatly with these general physical principles also reflects a failure to satisfy a meta-principle of scalar invariance which he requires for these general principles to govern all manner of physical entities.

As to the first claim, Gassendi indeed holds that we should expect different atoms to move at variable rates<sup>52</sup> but not because their central features differ. By contrast, macro-sized bodies should have variable rates of motion because of factors such as size, internal composition, and external resistance or attraction. In the case of atoms, however, such external factors should be superfluous given their internal and constant impulse to motion. Further, there is no relevant sense of internal composition since atoms are solid, containing no vacua—and as such are not physically divisible. Thus if atoms vary in their speed, one might suppose this to result from at least one atomic feature such as size, shape, or weight also varying.<sup>53</sup> Yet he instead accounts for variable rates of atomic motion by allowing that any two atoms may travel different distances over the same time on the grounds that, among their respective collected states-in-motion, there may also be states of rest.<sup>54</sup> Hence atoms may

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<sup>52</sup> How to measure rates of atomic motion is another question altogether, wholly unaddressed.

<sup>53</sup> As we have seen (chapter nine), atomic shape varies greatly and atomic size varies some; even atomic weight may vary, depending on which passage in Gassendi's works we take to be definitive.

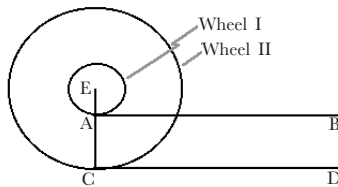
<sup>54</sup> Gassendi introduces the notion of atoms at rest by way of an analogy with a proposed solution to the paradox of Aristotle's Wheel (*rota aristotelis*)—which he discusses among his attempted resolutions of the paradoxes of motion classically taken to have anti-atomist consequences (*O I* 340–342; on the classic problem, q.v. Israel E. Drabkin, "Aristotle's Wheel: Notes on the History of a Paradox", *Osiris* 9 (1950), 162–198). The solutions he proposes rely on special features of atomic motion. In this paradox, wheel I of circumference  $x$ , in the middle of a wheel II of circumference  $n > x$ , are fixed together such that, when the larger wheel travels a given length, they appear to both travel the same lengths (as measured along tangents

move at different rates when their motion at individual instants is summed over together with the variable instants of interspersed rest. Accordingly, for those atoms where there are equal instants of rest, their motions taken in the aggregate should be identical, as they would be were there no states of rest.<sup>55</sup>

At any event, it is not clear why, without factoring in states of rest, Gassendi should have expected atoms to move at uniform rates. One might take him to have inferred that atoms should have a constant and equal speed (degree of motion) given their inherent, and equally constant, degree of mobility. Yet constant and equal mobility does not yield constant and equal velocity, which Gassendi undoubtedly recognized. Alternatively, some commentators such as Pancheri have suggested that Gassendi simply follows a view sometimes attributed to Epicurus on the basis of *DL X 61*.<sup>56</sup> In that passage, Epicurus

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AB and CD extending from the radii drawn from center point E of both circles to points A and C, respectively) in the same time though the distances traversed by these wheels over the same period of time *should* differ by some factor of  $n-x$  (see diagram below). Gassendi's solution is to suggest that any two such wheels travel identical lengths—arriving at the same place at what seems to be the same time—because the inner wheel which he supposes *should* travel faster rests along its path in motion. This solves the paradox, he claims, by factoring in rest as a normal component of measured velocity, and so distinguishing between truly identical speeds (identical distances traversed in identical times) and merely apparent identical speeds (distinct distances traversed in identical times because of differences in rest time). By analogy, then, atoms may travel at different rates even if they otherwise move at the same speeds because of intervening rest states. Thanks to Carla Rita Palmerino for discussing Gassendi's use of this analogy.



<sup>55</sup> *O I 355a*. In sum: if atoms have internal impetus yet pause occasionally, the distances they travel over a given time are relative to the ratio of their total time in motion to their total time at rest. Dijksterhuis (430) compares this with measuring the density of bodies by the ratio of their total atomic mass to their total volume (comprising atoms and void). Yet this comparison is not quite apt: the ratios in the former case—without incorporating velocity—are only partial functions of the distances traveled over a given time, whereas in the latter case the ratios alone give the densities.

<sup>56</sup> Q.v. Pancheri (1972), 161–162.



claims, somewhat confusingly, that atoms all travel at a speed which is faster than one which we may contemplate. The problem with this interpretive suggestion is that it does not follow that atoms all travel at the *same*, inconceivably fast speed.<sup>57</sup> Moreover, Gassendi never quite endorses this view as his own. The closest he comes is in various glosses on the Democritean and Epicurean view, such as this one: “. . . whatever way the atom moves in the boundless void...it always moves with the same speed and does not change its path, as long as a meeting with obstacles capable of changing it does not take place.”<sup>58</sup> Though he cites such ancient views approvingly, he does not defend the constant and equal speed thesis by independent argument.<sup>59</sup> More problematically still, this view does not guarantee uniform rates of motion across distinctive atoms; the passage cited here, for example, merely suggests that for any given atom moving in the void, it will retain its particular speed (which could conceivably differ for other such atoms), obstacles notwithstanding.

Regardless of whether Gassendi needs to maintain the uniformity of atomic motion—or else that there should be instants of rest—these views represent an apparent conflict with Gassendi’s notion of an innate motive principle, which does not accommodate easily, if at all, states of rest. Further, these views contradict the intuitive notion that bodies should vary in their rates of motion as a direct consequence of their varying in size or shape, let alone their weight. The first difficulty arises from the suggestion that atoms may actually cease to move—a possibility which Gassendi should abhor insofar as, according to the standard interpretation, he takes their internal impetus to be constant. That there could be, after all, states of atomic

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<sup>57</sup> In offering the notion of speed so fast as to not be detectable in practice, this ancient view curiously (if broadly) anticipates the modern conception, according to which bodies in motion have instantaneous velocity (so fast as to not be detectable in principle) in each instant of motion. The modern conception was, in any case, unavailable to Gassendi; indeed, as Richard T.W. Arthur details (unpublished manuscript (2004)), such a conception was not even shared by Galileo, to whom it is standardly attributed.

<sup>58</sup> *AN* 422; q.v. also *O I* 273b, 276b, 285a.

<sup>59</sup> Antonia Lolordo suggests that Gassendi rejects the Epicurean notion of all atoms moving at the same speed, on the grounds that God alone determines speed of atoms, such that their speed can be fixed or varied according to divine reason (*O I* 335b); q.v. (2005b). Naturally, had Gassendi wanted to preserve the Epicurean picture, it would be easy enough to stipulate that divine reason has it that all atoms move at the same speed.

rest is instead consistent with the rejected dispositional interpretation of the internal principle (the view that such a principle represents no more than a *potential* for motion). Ironically, it is only because the standard interpretation says that atoms are constantly in motion (at uniform speeds) that we should require an account of variation in atomic motion. This requirement leads to Gassendi's embrace of the atoms-at-rest proposal, which as we have seen does not sit well alongside the standard interpretation.

But what support does Gassendi adduce for the proposal that atoms may be at rest? One element of support is his suggestion, following Epicurus's view of atomic collisions as checks (*ἀντικοπή*), that moments of collisions constitute moments of rest.<sup>60</sup> Another possible source of support here is the claim that atoms constitute coherent solids just in case they remain fixed in position, either because they are held in place by hooks or pressure or simply in virtue of their shape and resulting fit with surrounding bodies.<sup>61</sup> This last point is unsatisfactory, though, because fixed position is not the same thing as a state of rest, and Gassendi even states that such atoms may continue to move, perhaps (for example) by vibrating.<sup>62</sup> The first suggestion is more plausible, but if the impetus were truly internal and constant it is hard to see how collisions could strip atoms of this feature, even momentarily.

Yet the main difficulty is that Gassendi ignores here a principle to which he subscribes elsewhere, that the character of bodily motion is determined by the qualities and interactions of the bodies in motion, not their states *per se* (such as rest or motion).<sup>63</sup> Thus, in his account of motive force among composite or macro-sized bodies, he proposes that the direction and velocity of composite bodies is not determined by the motion *simpliciter* of the bodies' constituent atoms. Rather, it is determined by the atoms' positions (and, given that they travel in

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<sup>60</sup> This point is made by Rochot (1944); and J. R. Partington, *A History of Chemistry* (London: MacMillan and Co., Ltd., 1961), vol. 2, 462. Regarding Epicurus's similar views, q.v. *Her.* 46–47; Lasswitz (1890), volume 2, 174 ff.; and Bailey (1928), 329.

<sup>61</sup> This also yields the variety of qualities, e.g. heat; q.v. *O I* 394f, following Epicurus.

<sup>62</sup> “. . . even in compound bodies atoms continue to move (imperceptibly, to be sure) in an uninterrupted fashion . . .” *O I* 279a.

<sup>63</sup> Indeed, accounting for such variety cannot even accommodate all manner of appeals to those states: an appeal to motion to *explain* motion is either incoherent or trivial—and Gassendi's appeal is instead focused on rest states and their being interspersed with motion states.

straight lines, the corresponding directions of their trajectories) as well as their angles of deflection upon impact with one another.<sup>64</sup>

On the micro-level, though, a different account of variation in motion (fewer or greater instances of atoms coming to rest) is required, for at that lower level we cannot appeal to the qualities and interactions of the selfsame atoms. The difference between these accounts is consonant with other distinctions that Gassendi draws between objects of the macro- and micro-realms: the innate motion of atoms is not diminished by external factors, nor is their motion composed of that of any internal parts, for they have none. However, such distinctions do not rule out the possibility that—following a commonplace of the mechanical philosophy—if their inherent features of shape, size, or weight vary, then so too should their rates of motion.

Indeed, for Gassendi, atoms may have distinctive sizes and shapes and, given that they cannot (for lack of void) have distinctive densities, they should be capable of differing by weight (considered as mass), too. It might be objected that, since atomic weight is equated with atomic motion and the latter is taken to be constant, we should infer that the former is supposed to be constant, too. Yet this equation only begs the question, and proscribes variation in atomic motion given that atomic weight may actually remain constant, as Gassendi insists.

Perhaps most damaging to this proposal, though, is the notion that, once it is assumed that atoms may come to a rest, there is no need to appeal to interspersed rests among instants of motion to yield variety across completed motions. For if atomic rests are possible, then such atoms can decelerate or regain their original speed only after first accelerating from rest. This suggests that variation in rates of motion is possible even across single instants of atomic motion, and that such variation may be brought about by interactions with other bodies such as constraints or collisions.<sup>65</sup> Consequently, this sort of variation should be pervasive, without the need to appeal to interspersed rests, leaving open the question as to why he thinks we need that account to explain the *rota Aristotelis* problem or variation in atomic motion.

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<sup>64</sup> *O I* 384.

<sup>65</sup> This assumes, per Gassendi's view, that deceleration and acceleration are not spontaneous.

A second significant puzzle regarding internal atomic impetus concerns the conservation of total momentum. In the background is the principle of conservation proposed by Descartes. This principle says that the total momentum of all matter is conserved in that the sum of momentum, gained and lost through accelerations and decelerations across all matter (or all space—these are equivalent for Descartes) remains constant.<sup>66</sup> It would be strange to think of a like principle in Gassendi's physics: that should entail summing over momentum gained and lost by atoms, as the least bits of matter, yet (when not discussing atoms at rest) Gassendi supposes these to sustain their own constant and internal impetus, neither accelerating nor decelerating.

All the same, he proposes something that looks like a principle of conservation, according to which there is no overall loss or gain of impetus among colliding atoms:

... when one atom impacts upon another, it receives as much repulsion as it gives the other impetus...<sup>67</sup>

Not only is there an overall conservation of momentum, then; there is also conservation of the momentum particular to each atom.<sup>68</sup> But is there any mutually compensating transfer of momentum in such collisions? As Dijksterhuis has noted, this principle differs from the cartesian one in that the former has it that total momentum is conserved in the sense that the sum of accelerations and decelerations for each atom remains constant—at zero—given that atoms always retain their internal impetus.<sup>69</sup> In other words, the exchange of repulsion and impetus will always be even in Gassendi's scheme, because those must amount to zero: there is no such compensatory transfer of impetus.<sup>70</sup>

<sup>66</sup> *AT* VIII 61–62; *PP* II § 36.

<sup>67</sup> *O* I 343b; q.v. also *O* I 336a.

<sup>68</sup> MS Tours 709, folio 306 r-v, as cited in Brundell (1987), 78, 193. One point in favor of this proposal is its coherence with Gassendi's account of atomic weight as a necessary and definitive feature. For if an atom's weight cannot change, and weight just is the motive force internal to atoms, then this original motive force—hence their momentum—should not change either.

<sup>69</sup> Dijksterhuis (1961), 410, 429.

<sup>70</sup> Bloch (1971, 221–222) offers a very different interpretation, citing Gassendi's suggestion that, in the case of aggregate bodies, there is a transfer or 'compensation' (*compensatio*) that occurs in the collision of two such bodies, with the result that the total amount of motion is conserved; cf. *O* I 343b. That suggestion indeed closely resembles the classic conservation principle, yet for Gassendi the classic principle as applied on the atomic level must be seen as redundant given his view that

Clearly, Gassendi addresses the conservation of momentum from quite a different perspective than do authors of the classic principle. As Dijksterhuis suggests, views like Descartes's entail conservation whatever the variations in the momenta of individual bodies and their constituent corpuscles, whereas Gassendi's view entails that conservation results from maintaining precisely the opposite situation—that is, keeping atomic motion uniform. Once set in motion (in Creation), atoms continue on indefinitely with their internal impetus intact. This proposal fails to guarantee conservation of momentum for Gassendi, however, as he views the 'non-natural' or violent motion of macro-sized bodies as resulting (along with all motion on the macro-scale) from the natural motion of their constituent atoms. The additional momentum produced by such violent motion in the collision of macro-sized bodies accordingly results in momentum added on the macro-level with its source in the collision, plus the aforementioned initial momentum with its ultimate source on the micro-scale.<sup>71</sup> Hence there is a *surplus* of momentum, beyond that which his conservation principle sustains. On a classic version of the conservation principle, Gassendi might well accommodate innate atomic motion: whereas the totality of momentum must be conserved in *some* fashion, the classic principle itself is neutral as to innateness or change in states of motion for any given matter. His own version of the principle, on the other hand, straightforwardly affirms the innate and unchanging nature of atomic motion. This makes it impossible to also accommodate such additional sources of momentum as his view entails in composite bodies.

Finally, a third source of difficulties for the internal impetus theory concerns the principle of inertia. Alexandre Koyré (1955) and other commentators have suggested that Gassendi's inertial principle

the source of all motion is supposed to be in the atoms themselves. Moreover, a viable conservation principle governing atoms *should* govern momentum generally, and it turns out that in Gassendi's framework there are additional sources of momentum at the macro-level; q.v. below.

<sup>71</sup> *O I* 343b. Gassendi does not allow, however, that violent motion of macro-sized bodies originates in collisions or combinations among atoms, and suggests instead that violent motion results from collisions on the macro-scale. But this suggestion cannot work: for example, collisions among supra-atomic bodies and atoms should require that the colliding atoms play a role in explaining the violent motion that results. Gassendi is apparently trying to avoid any possibility of violent motion among atoms, though this last example suggests just such a possibility, and nothing in his expressed views rules it out.

holds on the level of macro-sized objects but not on the level of atoms; in this regard, his physics is not scalar invariant.<sup>72</sup> The depth of this difficulty is great, for atomic motion in Gassendi's account is fundamentally and ineradicably noninertial. His atoms—like those of Epicurus—are fundamentally noninertial because they neither gain nor lose velocity in collisions or impacts, nor do they ever come to a complete rest, at least in the sense of losing their propensity to motion. They are ineradicably noninertial because the character of their motion is determined by God, who ostensibly has the power to generate motion not governed by the principle of inertia.<sup>73</sup> The internal impetus theory thus conflicts with Gassendi's general physics.

Consider the principle of inertia he offers in *De Motu*:<sup>74</sup>

You will ask in passing what would happen to that stone which I claimed could be imagined in empty space if it were roused from its state of rest and impelled by some force. I answer that it is probable that it would move indefinitely in a uniform fashion, slowly or rapidly, depending on whether a small or great impetus had been imparted to it. I take my proof from the uniformity of the horizontal motion I have already explained since it [the stone] would apparently not stop

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<sup>72</sup> Koyré's criticism (1955, 108–109) is complicated by his conflation of two problems; q.v. Alexandre Koyré, "Le Savant", in *Centre International de Synthèse—Pierre Gassendi—Sa Vie et Son Œuvre, 1592–1655, Journées Gassendistes, Centre International de Synthèse, Avril 1953*, ed. Bernard Rochot, Alexandre Koyré, Georges Mongrédien, and Antoine Adam (Paris: Albin Michel, 1955). First, atoms have their own source of motion (which by itself prevents their motion from being inertial; see below); second, such continuous motion on the part of atoms cannot account for disparate speeds among macro-sized bodies (*res concretæ*) without the necessity of discontinuous motion among the latter (which yields a different sort of noninertial motion). Subsequent commentators, including Bloch (1971), Messeri (1986), and Thomas Lennon (1993, 14), have partially disentangled these two points.

<sup>73</sup> This is consistent with the suggestion of Margaret Osler (1994, 48–56) that Gassendi is committed to a voluntarist theology that shapes his general metaphysics and views of empirical knowledge. The case is not entirely plain for such voluntarism in Gassendi's thought, though, as we can see in his notion of absolute space not being subject to divine creation or destruction.

<sup>74</sup> Gassendi has the distinction of being the first to publish a fully satisfactory version of a principle of inertia, as Koyré noted; q.v. *Études Galiléennes*, Volume III (Paris, Hermann: 1966). Other, less satisfactory versions of the principle had been propounded not long before by Beeckman (in his unpublished Journals), Galileo (in the inadequate terms of circular motion), and Descartes (in *Le Monde*, which did not see publication until after Descartes's death). Q.v. Beeckman (*Journal I*, 10, 24 and 253), Galileo (*EN XIII*, 243), and Descartes (*AT XI*, 43–44); also P. A. Pav, "Gassendi's Statement of the Principle of Inertia", *Isis* 57 (1966), 24–34; Bernard Rochot, "Beeckman, Gassendi et le Principe d'Inertie", *Archives Internationales d'Histoire de Science* 31 (1952), 282–289; and Bloch (1971, 223–228).

for any other reason than the influence of perpendicular motion. Hence, as there is no influence of perpendicular motion in space, whatever direction the motion has started in, it would behave like the horizontal one and would not be accelerated or slowed down, and therefore would never stop.<sup>75</sup>

According to this version of the principle,

- (I) a body is at rest or else moves at a uniform rate along a rectilinear path unless subject to some force, which may either accelerate or decelerate the body, and/or change its path.

That the motion of bodies is naturally inertial suggests that the only way they move *not* in a straight line is when something disturbs what would otherwise (and naturally) be their rectilinear path. One consequence is that such inertial motion and rest are equivalent states so that, contrary to what the Aristotelians maintained, there is nothing ‘unnatural’ or ‘violent’ about the state of a body in motion and not falling toward the Earth. This is because the inertia theory recognizes that rest is a special case of uniform rate of motion (that is, equal to zero) and that, by contrast, acceleration and deceleration of any kind or degree entails change in the rate of motion. Accordingly, for the inertia theorist, such change is the non-standard mode (what the Aristotelians might have called an ‘unnatural’ state, except that they consider change as a mode rather than a state *per se*).

What sorts of bodies behave in these ways? Gassendi presents the principle without exceptions, so one might well infer that it is maximally general in scope. Accordingly, one might expect micro-sized as well as mid-sized objects (like stones in an idealized void deep in space—Gassendi’s example) to behave inertially.

But as we have seen, Gassendi’s primary micro-sized objects—atoms—are initially and permanently endowed with motion by God. Indeed, they cannot fail to move at a fixed rate. This suggests, contrary to (I), that atoms as created may neither decelerate nor accelerate after the addition of force, as impressed in collisions. Moreover, although Gassendi stipulates that atomic motion follows a rectilinear path, he makes this point quite independently of (I); atoms would move in straight lines even if the principle of inertia was not part of Gassendi’s physical picture. While he wants a thoroughly atomist

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<sup>75</sup> O III 495–496 (*De Motu*, first letter, §XVI); B 139.

physics, if the principle of inertia does not apply to the microlevel, then the very core of his theory of matter and motion need not obey his general physics. Koyré is on good grounds for concluding that Gassendi's science is inconsistent.

A worse corollary of Koyré's proposal is that the principle of inertia should not apply to anything bigger than atoms, either. Gassendi wants accounts of macro-sized phenomena to be reducible to accounts of micro-sized phenomena, so if the corpuscles themselves do not obey his principle of inertia then neither should their aggregates be expected to. Unfortunately, it is not clear how their aggregates could do so.

To examine this matter in greater detail, consider first Gassendi's formulation of a principle of inertia in his *De Motu* (and later in the *Syntagma*).<sup>76</sup> In Article XVI of the first letter of *De Motu*, he entertains the imaginary case of a motionless stone in empty space. If a force impels the stone, he writes, then

... it is probable that it would move indefinitely in a uniform fashion, slowly or rapidly, depending on whether a small or great impetus had been imparted to it.<sup>77</sup>

Why? Consider the uniformity of horizontal motion, which is only brought to an end by a countervailing perpendicular motion. But as there are no such countervailing motions in the imaginary empty space, so the stone must travel forever in that direction. Gassendi writes:

... whatever direction the motion had started in, it would behave like the horizontal one and would not be accelerated or slowed down, and therefore would never stop.<sup>78</sup>

Next, he offers this experimental proof: Take a piece of string and hang a stone on it. If you push the stone forward, its motion would

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<sup>76</sup> Of the letters in *De Motu*, the first two were published in 1642; all three appear in *O* III 478–563. The first two were written to Pierre Dupuy (at Paris, November 20 and December 11, 1640; first published in 1642), and the third to Joseph Gaultier (August 10, 1643), in response to objections posed by Jean-Baptiste Morin to the letters to Dupuy (which were in turn later published as *Apologia in Jo. Bap. Morini*, Lyons, 1649). Subsequent discussions appear in *O* I 349b–350a, 354b–355a, as well as *AN* 481–481.

<sup>77</sup> *O* III (*MI*) 495; *B* 139.

<sup>78</sup> *O* III (*MI*) 495; *B* 139.



be uniform and perpetual except for the air resistance, and the weight of the string. Indeed, at first glance, it seems that the motion actually *is* uniform and perpetual. This is because the string neutralizes the stone's attraction to the Earth, so there is no countervailing perpendicular motion. Now, assume the stone is in a vacuum and the string is replaced by a weightless ray with no parts (it is in either case motionless, but here Gassendi emphasizes that it is in this instance weightless as well). Set the stone in motion and it will continue in uniform fashion for perpetuity. Gassendi concludes that

. . . a motion imparted in empty space where nothing either attracts it or holds it back or resists it in the least would be uniform and perpetual. . . .<sup>79</sup>

We can see this principle enacted in the regular course of things—that is, considering more ‘familiar’ phenomena than weightless rays and stones in vacuums—if we simply imagine that everything aside from a given body set in motion has been annihilated.<sup>80</sup> As a result, the body's motion will be uniform, because no other body can perturb its rate of motion; perpetual, because no other body presents an obstacle; and rectilinear, because no other body disturbs or distorts its path.<sup>81</sup> That bodies in our experience do not feature such motion is an indication of the countervailing perpendicular forces that—outside the world of the thought experiment—act on those bodies. To arrive at a universal principle of rectilinear inertia, then, Gassendi needed to first abstract away all those other bodies that, because of attraction or repulsion, might otherwise hinder uniform and perpetual motion.<sup>82</sup>

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<sup>79</sup> *O* III (*MI*) 495; *B* 141.

<sup>80</sup> Gassendi is drawing on a tradition of proofs by reference to hypothetical annihilation, such as were offered by Thomas Bradwardine and other medievals—in their case on behalf of an extramundane void space; q.v. Edward Grant, “Medieval and Seventeenth-Century Conceptions of an Infinite Void Space beyond the Cosmos”, *Isis* 60 (1969) 1, 39–60.

<sup>81</sup> The rectilinear character of inertial motion is the great novelty of Gassendi's account. In contrast to the Galilean account, Gassendi rejects the notion that natural uniform motion is circular (as is characteristic of Aristotle's account as well). Descartes's inertial motion is also rectilinear, in principle, though his rejection of the void has as a consequence there being no possibility of actual rectilinear inertial motion.

<sup>82</sup> Gassendi's use of abstraction to derive a principle of inertia is novel, not simply because of his use of counterfactuals, which are found as well in medieval argument. Rather, it is novel because he appeals to abstraction to distinguish the behavior

To clearly distinguish this view from the impetus theory to which it is opposed, Gassendi points out in Article XIX of the same letter that the motion of a moving body is transferred to it by the mover. Impetus theory is wrong, then, because there need not be a continuous action on the part of the mover for the motion to continue. He notes that the mover bears a transferable motion to begin with only because it is itself in motion. Indeed, anything propelling any other thing must itself be in motion:

... to understand how this transference takes place, reflect on the fact that before the stone is hurled into the air, it is joined to the hand for a certain period of time and may be considered one and the same with it as a single moving object because one and the same motion applies jointly to them both, or because the hand moves the stone with the very same motion as itself. . . .<sup>83</sup>

And further on, he generalizes this point:

... what I say of the hand may be understood to apply to any other physical mover. Indeed, there is no mover in nature which is not in motion itself, so that it accompanies the object it is moving a certain distance, directs it on the course it will hold, and by passing on an invested right as it were, impels it; nor would it ever impel something by simple contact without a forward motion of this sort.<sup>84</sup>

This last claim might be confused with the suggestion that everything *is* in motion, which would explain why Gassendi could have taken the principle of inertia to be consonant with the view that atoms are in perpetual motion. Yet this claim entails no more than the view that anything which *may* move something else needs to be in motion when it does that moving. We can guess that Gassendi was, or at least should have been, aware of this much from his mention in this very passage of the possibility that a body ‘finally comes to rest’.<sup>85</sup>

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of bodies as it would be were they independent of the force that gravity actually exercises on bodies falling to Earth.

<sup>83</sup> *O* III (*MI*) 498b; *B* 144.

<sup>84</sup> *O* III (*MI*) 498b; *B* 144.

<sup>85</sup> As Rochot (1952) and Fred Michael have pointed out, the Epicureans, too, have something that looks like a principle of inertia—and this may well have been a source of inspiration for Gassendi. But this is not Gassendi’s announced path to that principle; he comes to it (in *De Motu*) by first wondering about the cause of the motion of bodies falling to Earth (where he offers a corpuscularian account of the Earth’s magnetic attraction), and then asking what might happen were one to

From this brief review of Gassendi's principle of inertia, it emerges that while his atoms travel in straight lines, they do so for the wrong reasons. Thus "the innate motion of atoms is straight and exceedingly swift",<sup>86</sup> as he puts it, yet this rectilinear motion is not sustained for any inertial reasons but by an impetus internal to the atoms. Further, Gassendi's atoms move in straight lines because this is the course he thinks God designates when investing them with the proper impetus for perpetual motion. Atoms move in straight lines and not swerves or any other pattern because God wants them to move thus—and not because they conform to inertial behavior. As

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position a body in space but take the Earth away, along with all other bodies in the space.

Further, the Epicurean account—which specifically covers the motion of atoms—is incompatible with a principle of inertia. Consider Epicurus's suggestion that atomic motion is generally linear, and that

The atoms are in continual motion through all eternity. (*DL X 43*)  
 which, together with the proposal that

When they are traveling through the void and meet with no resistance, the atoms must move with equal speed. (*DL X 61*)  
 yields an account of atomic motion that indeed looks close to the inertial picture. That is, it seems Epicurean atoms move not only rectilinearly *and* perpetually, but also—as long as nothing resists their motion—uniformly. Yet there are two significant problems from an inertial perspective. For one, Epicurus never suggests that the otherwise perpetual character of atomic motion is subject to the resistance of other objects (atoms cease to move rectilinearly (that is, downward) because of resistance provided by the *clinamen* or swerve, yet that source of motion is an invention of latter-day Epicureans). To the contrary, in the passage from *DL X 43* quoted above, Epicurus says the motion of atoms lasts forever. For another, even his account of the uniform velocity of atoms must be, in the end, noninertial. To be sure, the well-known passage from the *Letter to Herodotus* certainly suggests the velocity of atomic motion has a properly inertial character:

Neither will heavy atoms travel more quickly than small and light ones, so long as nothing meets them, nor will small atoms travel more quickly than large ones, provided they always find a passage suitable to their size, and provided also that they meet with no obstruction. Nor will their upward or their lateral motion, which is due to collisions, nor again their downward motion, due to weight, affect their velocity. As long as either motion obtains, it must continue, quick as the speed of thought, provided there is no obstruction, whether due to external collision or to the atoms' own weight counteracting the force of the blow. (*DL X 61*)

And yet this suggestion falls short. One problem—which revisits Gassendi—is that no obstruction or collision can wholly decelerate the rate of motion in any case, given that atoms must remain in motion. More broadly, though, even when atoms move at a uniform rate unless obstructed, by Epicurus's account they may also move noninertially with respect to the perpetuity or rectilinearity of their motion, which is to say they are not moving inertially at all.

<sup>86</sup> *O I 385a*.

a matter of divine planning, it does not matter *why* God might want to start things up this way, though given the mysteries and omnipotence of the Divine it is not likely because rectilinear motion alone conforms to the principle of inertia.<sup>87</sup>

Overall, however, the primary factors rendering atomic motion noninertial are that atoms have an innate weight that Gassendi equates with a constant and internal propulsion or impetus and that, should atoms not come to rest, they would move at constant velocity. These features of atomic motion conflict with the principle of inertia in several ways. For one, if the degree of impetus in, and velocity of, each atom remains constant, then no force either augments or diminishes their velocity, which renders their motion uniform—independent of external action. Even supposing genuine variability in the speeds of atoms (that is, without interspersed rests), acceleration among Gassendi's atoms should be noninertial anyway because it would occur not only with the addition of external action (such as a new force) but also with the simple removal of obstacles from the path of an atom. For although atoms move in some way even when an obstacle blocks their path, they do not continue along their previous trajectory at 'initial' or pre-obstacle speeds—and when such obstacles are removed they immediately resume their previous speed and direction of travel.<sup>88</sup> Moreover, as we have seen, while Gassendi's view of atomic mass commits him to unceasing atomic motion, he allows anyway that atoms can be at rest. Given that atoms left to themselves will keep moving, such rests as occur must entail interaction with other bodies, including moments of collision with, and being fixed in position by, other bodies. An untoward consequence of this last claim is that viewing the motion of atoms as

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<sup>87</sup> One might counter here that, as God plans providentially for the path of atoms, so too, there is a divine plan that dictates the inertial behavior of bodies. But Gassendi never links his inertial characterization of bodies in motion to God's plans. Indeed, he suggests the contrary—that God's role is insignificant here—in proposing that proximate causes of changes in rates or directions of motion are the forces transmitted by other bodies. Since God sets matter in motion at the beginning of time, Gassendi can still talk of an ultimate divine responsibility for the sum of changes in the physical universe, but this is far short of the suggestion that divine maintenance is required to sustain the adherence of bodily motion to a principle of inertia.

<sup>88</sup> Were atoms to continue to vibrate or spin at some non-negligible velocity, their subsequent acceleration might be thought to satisfy inertial requirements—but without preserving rectilinearity of motion.

satisfying criteria for inertial states fails to account for rest states which, inertially speaking, should occur when such bodies are not in motion—including, notably, when no external force impels or compels the body. In fact, this view constitutes a reversion to treating motion and rest as two drastically different states, motion being ‘normal’ and involving no other bodies, and rest being aberrant and requiring the actions of or relations with other atoms. Yet the principle of inertia has it that rest and motion are equivalent states—in contrast to the Aristotelian conception.

Problems of these sorts arise given the expectation that atoms should obey the same mechanical principles of motion as supra-atomic bodies. This in turn is a reasonable expectation only if Gassendi supposes that his basic mechanical principles are scalar invariant, such that his atoms behave like any other bodies are understood to behave in his physics. He makes no such claim and it may be thought that, unlike Descartes, he has no clear need of a scalar invariance thesis. However, that he should have found such a thesis compelling is suggested by his proposal that the motion of supra-atomic aggregates is composed of the motion of their constituent atoms.<sup>89</sup> This compositional view should recommend scalar invariance if motion is to be understood in the same way, regardless of scale or—what amounts to the same thing—if principles such as (I) are to have a truly universal scope.

In fact, though, the compositional view gets Gassendi in trouble, precisely because he blocks off appeal to scalar invariance. This result stems from the thoroughness of his compositional stance and commitment to the unchanging internal motive force (*vis motrix*) of atoms. To begin with, one consequence of his compositionism is that atoms bound in even the smallest of aggregates (‘concretions’ or ‘molecules’) feature inherent motions that, if countervailing, may cancel each

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<sup>89</sup> “. . . the principle by which all things in nature and all the things that compose them are moved, seems to be in those things because of the natural movement of atoms, so that if, when atoms are excited differently within a given body, those that are more mobile and separated than others together endeavor [to move] towards someplace, they push the whole body there—which as a result drags with it the rest of the atoms.” *O* I 338a. The view that the motion of supra-atomic bodies is a composite, comprising the sum of motions of its constituent atoms can be found in Epicurus (q.v. Bailey, 1928, 347–348). Lucretius (*DL* X 62) assumes the composite nature of *causal agency* though he does not specify that this entails the composite nature of *motion*.

other out or at least slow down the aggregate's overall motion in a particular direction.<sup>90</sup> Another consequence is that all atoms of an aggregate moving in the same direction compel the aggregate to move in that direction, too. If not all constituent atoms move in the same direction, then the aggregate should move along the path traced by the greatest number of atoms.<sup>91</sup> Moreover, if some atoms in a body move slower than others, the faster ones should force the slower ones to keep pace by propelling them into fixed positions so they move along with the faster ones. This sort of fixed positioning also facilitates repetitive motion, Gassendi maintains, and so allows bodies to develop 'habitual' movements. In short, the nature of an aggregate body's movement is a direct function of the internal impetus of the atoms it comprises. When these aggregates grow, then, their speed increases relative to that of the atoms added:

... as other atoms join on to them, the molecules become a little larger and move slower or faster in proportion to the motion of the newcomers. Again, as further atoms are added, the molecules constantly become bigger and bigger until they are perceptible and whatever motions they have can be observed. Finally, the object comes to the notice of the senses; and not only single atoms, but also somewhat larger clusters and masses are gradually united to it and incorporated in it. In such a way all bodies, large as well as small, may be made and may execute particular motions and the actions particular to them in conformity with the fabric of the atoms. Hence it happens that whatever motion or action natural bodies have ought to be regarded as received from their atoms.<sup>92</sup>

This scenario, however, suggests why an appeal to scalar invariance is not possible when speaking of the aggregate bodies they form. Gassendi says that *whatever* motion such aggregates have they receive from their constituent atoms—yet as we have seen, these smallest bodies move noninertially.<sup>93</sup> Worse still, if their motion should be

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<sup>90</sup> "... the smallest solid objects, or molecules, are first made from atoms colliding into each other and ... to the extent that they contained the impetus of more than one atoms, they should be driven off in some direction, but yet ... their movement should become somewhat more sluggish because of the cancellation and counteraction of the [atomic] motions." *O I* 337a; *B* 422.

<sup>91</sup> *O I* 384b.

<sup>92</sup> *O I* 337a–b; *B* 422–423. As Gassendi notes, this view is borrowed from Lucretius (*RN II*, 132–139).

<sup>93</sup> Gassendi also hints in this context at one empirical test of his atomism; since the motion of aggregates is determined by their constituent atoms, and we can

not governed by the same principles governing the motion of all other, larger bodies, then we must satisfy the further need for an account of how inertial motion arises or emerges from noninertial motion. Such an account is not forthcoming, given Gassendi's view that aggregate motion just is the sum of the constituent atoms's motion.<sup>94</sup> It is not reasonable to assume that we might simply (and consistently) sum over noninertial motion and get inertial motion.<sup>95</sup> Hence a return to a scalar invariance thesis seems desirable, though Gassendi does not explicitly embrace one.<sup>96</sup>

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detect variations in the motions of aggregates, in principle we ought to be able to infer the motion of even single atoms from slight enough variations on the macro-level. Confirmation is hard to attain, and not only because such variation would be so minute as to escape any means of detection available to Gassendi or anyone after him for three hundred years. A worse problem is that we would not likely find such an inference compelling unless we previously accepted that macro-sized bodies are aggregates of atoms. On the other hand, a more viable falsification hypothesis lurks here: if the rates of change in the motion of macro-sized bodies varied widely and independently of minute additions to their total mass, we should have no reason to think such bodies are aggregates of atomic components that are the source of their motion. This line of reasoning is, alas, also not possibly pursued in Gassendi's context given the infancy of microscopy in his time.

<sup>94</sup> One basic reason that Gassendi cannot appeal to inertial motion in *res concretæ* (composite bodies) as a property emerging out of atomic noninertial motion is that the motion of atoms remains noninertial even when they are aggregated.

<sup>95</sup> It might seem that it should be possible to sum over noninertial motion and get inertial motion. For example, it might be thought that the forces of atoms in noninertial motion could cancel each other out such that the aggregate body they compose moved or was at rest inertially. It is feasible that aggregates could remain at rest or travel in rectilinear paths at uniform rates given compositionality and despite the distinctive behavior of their atomic constituents (indeed, this proposed resolution appears in some recent commentary; q.v. note 96 below). Yet this does not address whether such behavior among those aggregates can be characterized as inertial: how would they sustain such states, and what should happen if some other, countervailing force were introduced? It is those circumstances, and not the accidental paths or rates of the moving body, which are prescribed by the principle of inertia. Assuming a composition of atoms behaving noninertially, and a thorough compositionality, there is no guarantee that an aggregate so composed which happens to mirror inertial behavior over some period of time would continue to do so indefinitely. In any event, there is no reason to suppose (as one would have to, in order to resolve the conflict at hand) that such instances represent the standard case.

<sup>96</sup> Bloch (1971) arrives at the view that Gassendi's perspective is very much scalar *variant*, based on his review of Koyré's criticism of Gassendi as marrying the internal impetus of atoms with a principle of inertia. Koyré (1955) notes that, if atoms are always in motion given their inherent mass, then were they constrained and subsequently freed, they would not be at rest but begin moving without being compelled in any way, contrary to the inertia principle. Koyré focuses on Gassendi's reference to atomic rest as a means of accounting for any motion slower than that

Further puzzles and difficulties arise regarding the contribution atoms make to the motive force of aggregate bodies, relative to the meaning in this context of *vis* or 'force'. Much has been written about how to best understand, or even translate, *vis* in early modern philosophical and scientific writings. For his part, Gassendi tends to use the term to indicate that quality of macro-physical objects

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of the 'regular' atomic rate (*O I* 341b–342a), and suggests that such rest states present a possible way of allowing inertial motion to operate on the atomic level.

Bloch dismisses this line of reasoning, on two grounds. First, he notes, Gassendi does not make more than one mention of such atomic rest, whereas he makes repeated mention of the unceasing motion of atoms. The passage to which Koyré refers, in short, is idiosyncratic and apparently not reflective of Gassendi's considered view. Moreover, Gassendi is concerned there, not with accounting for the general nature of atomic motion but with resolving the *rota Aristotelis* problem, which is rather a question of characterizing macro-level motion (226).

It bears noting that, if Gassendi is proposing that atomic rest is possible, then it hardly matters whether the question he is addressing concerns motion on the macro-level or not: rest either is or is not a possible state among atoms. For Bloch's part, though, the resolution of this difficulty lies in distinguishing between the micro- and macro-levels as two different domains of reality. By his account, non-inertial behavior is suitable for atoms, inertial behavior is suitable for aggregate bodies composed of atoms, and the two kinds of behavior exist at the same time. Atomic, noninertial motion contributes, in concert, to the motion of macro-level bodies such that the noninertial behavior is not manifested on the macro-level (226–227; q.v. also Westfall (1971) and Pancheri (1978), 435–463).

One problem with Bloch's view is that Gassendi does not discuss two such levels of reality, as such, in the *Syntagma* or elsewhere. Another problem with this view is the degree to which, in one relevant sense, Gassendi appears to rely on scalar invariance (without enunciating such a thesis, and whatever other problems may pertain to such). Specifically, Gassendi needs scalar invariance to sustain the contribution of compositionality to a conservation of motion, for in adding the motion of multiple atoms, we should always get amounts in the aggregate that equal the sum of the individual motions. If not, then it would be possible to produce variable total quantities of motion—which for Gassendi is indexed to the quantity of atomic mass—in the universe. But he takes that total quantity to be fixed at Creation, hence the amount of motion in bodies must scale invariantly. This in turn precludes inertial behavior emerging from noninertial behavior.

Messeri (1987) takes another tack altogether. The basis of his view is Koyré's perspective: given that atomic rest is a core component of Gassendi's picture of atomic motion, there are attendant difficulties for sustaining inertial motion. Yet Messeri goes a step further, proposing that problems elsewhere in Gassendi's physics with inertial motion suggest that his commitments to the inertia principle should be taken as less central to his physics than his picture of atomic motion and rest. This assessment cannot be quite right, though, for the inertia principle shows up in several places in Gassendi's writings as a fundamental claim, whereas the notion of atomic rest is, as Bloch suggests, almost incidental to Gassendi's account of atomic motion. It is more plausible to assume that *each* of these views is reasonably taken as Gassendi's considered perspective—after all, both views survive to the *Syntagma* as finally edited.



which enables them to effect transit from one place to another.<sup>97</sup> Force, in other words, is effectively the ‘capacity to cause motion’.<sup>98</sup> In this regard, we may recall Jammer’s suggestion that, assuming a principle of inertia, ‘force’ in this last sense then looks like ‘capacity to cause acceleration’.<sup>99</sup> This result suggests in turn that, given the motion of supra-atomic bodies is ‘received from’ their constituent atoms, such motive force as we attribute to those smaller bodies may be seen as the capacity to cause motion and acceleration on the macro-scale. Indeed, this last suggestion reflects Gassendi’s primary concern with *vis motrix*, the discussion of which he places in the context of qualities of bodies—meaning generally macro-sized aggregates.<sup>100</sup> Following out an additional implication of compositionality, if we assume that the amount of motive force is proportional to the weight or motion in a given atom, then the amount of motive force in aggregates should be a function of the amount of such force in its constituent atoms. Gassendi, however, provides no details on this issue.

A troubling aspect of this picture is the possibility of a source of motion and acceleration among macro-physical bodies that makes

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<sup>97</sup> The classic discussions of the *vis* concept in recent historiography are Max Jammer, *Concepts of Force* (New York: Dover, 1957/1999); Mary Hesse, *Forces and Fields: The Concept of Action at a Distance in the History of Physics* (London: Thomas Nelson and Sons Ltd., 1961); and Westfall (1971). More recent treatments include Clarke (1996) and Sophie Roux, “Force”, in *Dictionnaire d’Histoire et Philosophie des Sciences*, ed. Dominique Lecourt (Paris: Presses Universitaire de France, 1999).

<sup>98</sup> Henry Margenau calls this a ‘prescientific’ sense of ‘force’ that was acceptable only when ‘motion’ was taken to indicate ‘increment in vector velocity’ and ‘cause’ was taken as ‘dynamic enforcement’; q.v. *The Nature of Physical Reality* (New York: McGraw-Hill Book Co., 1950), 223. By ‘prescientific’, he doubtless intends no slight on the physics through D’Alembert but something like ‘intuitive’ or ‘commonsensical’.

<sup>99</sup> Jammer further points out that, as a consequence of the development of a principle of inertia, ‘force’ has as well historically been taken to mean ‘whatever deflects bodies out of uniform motion in a straight line’; q.v. Jammer, “Force”, in Edwards (ed.) (1967), 209; and (1957/1999), 101–103). If Gassendi’s atoms move noninertially, then, he could not accept such an account of force. That such an account is not inconsistent with Gassendi’s use of the term provides further reason to doubt that his atoms are *supposed* to move noninertially. The unfortunate conclusion is that he did not realize that his inertial principle precluded his internal impetus theory.

Other, more familiar traditional views include the notions that ‘force’ refers to  $m \cdot a$ , and that ‘force’ is whatever balances a weight, so that force is equal to the amount of weight held in equilibrium. There is no evidence to suggest Gassendi subscribes to either of these last views.

<sup>100</sup> Q.v. *O I* 384 ff.

their motion noninertial, with no impact with other bodies required. Gassendi does not mind this result—indeed, it enables motion among persons without impact from other bodies.<sup>101</sup> However, this scenario is unacceptable from the standpoint of his principle of inertia, even if such a principle only applies on the macro-level.

The problem with Gassendi's view of atomic motion, in sum, is the same as that which afflicts his atomism on the whole: he seeks to explain motion (or other properties) on the phenomenal level by appealing to the basic elements of matter which he believes must have special, distinctive qualities in order that the explanations be truly informative. Such an appeal may seem a promising requirement for micro-level physical theories. It is, to be sure, a feature of much of the history of such theories, including present-day sub-atomic physics. Yet Gassendi fails to build into this form of explanation any guarantee that the special and distinctive qualities of atoms are consistent with the basic mechanical principles of his physics. In particular—and despite an absence of principles of motion such as govern only macro- or micro-physical worlds alone—his atoms apparently do not behave according to the rules of motion he stipulates as governing macro-sized bodies. This might not be a failure if he did not otherwise require a scalar invariant physics, such as would allow his compositional conception of atomic motion. Unfortunately, any attempt to establish such invariance would be hampered precisely by his compositionism, taken in tandem with his internal impetus account. There is a broader consequence of not being able to fold the special quality of internal impetus into a theory of motion

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<sup>101</sup> Non-human animals appear to move on their own as *animata* (without the impact of other bodies) yet they are moved by an internal *vis motrix*, which consists in the 'flame' of the animal soul—for Gassendi, a materially constituted *anima* of fire-atoms in constant motion (*O* II 505b). Human beings, who also have that material soul, additionally have a soul that is not constituted materially; hence the motion of their bodies has neither external nor internal material impact as cause. This point has a precedent in Lucretius, who emphasizes the free will of persons (*RV* 264f) as a means of arguing, via the composite nature of causal agency, for the existence among atoms of a source of such agency besides external impact or internal weight—this is the swerve (*clinamen*). Gassendi rejects the clinamen and embraces the composite nature of causal agency, as well as free will (*O* II 837–840; q.v. Osler (1994, 91–92) and Sarasohn (1996, 56–59)). Yet he does not follow Lucretius in concluding that there is any physical source of causal agency other than mass or contact action needed for atomic motion. The suggestion of another, *non-physical* source is a wholesale departure from the ancient atomist view.

consistent with principles of the general physical theory. In this way, the motion of atoms represents an exemplary case of the inability of atomic features to yield a satisfactory account of phenomenal features of the world.<sup>102</sup>

There is yet another, familiar problem in accounting for the motion of macro-level bodies through such special and distinctive qualities of atoms as their impetus. This is an instance of attempting to account for the mysterious by recourse to the equally mysterious—an old complaint about the explanatory schema of first, hylomorphism, then later, corpuscularian matter theories. This problem arises time and again in the many and varied uses Gassendi wants to make of his atomism, in all manner of scientific explanations; I next examine two such cases.

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<sup>102</sup> The other primary atomic features—size and shape—merit further discussion. In this context, however, suffice it to say that these features cannot bring on difficulties of the same order as does atomic motion because there are no principles governing size and shape at the heart of Gassendi's physics—save the notion that there is a physical minimal (which in any case is not a principle governing motion).



## CHAPTER ELEVEN

### EXPLANATORY USES OF THE ATOMIST HYPOTHESIS

Pierre Gassendi draws upon his atomist hypothesis in many, varied accounts of natural phenomena, across physical, chemical, biological, and geological domains. As we saw in chapter five, for example, his atomism is indispensable to his attempt to explain the results of the barometric experiments. What this one case does not indicate, though, is his broad conception of atomism as providing mechanically viable accounts of natural phenomena where none previously existed—whether because prior mechanical approaches were thought inapplicable or because no solutions as such approaches yielded were actually successful. This use of the atomist hypothesis is particularly evident in his accounts of attractive forces (such as magnetism and gravity) and the reproductive and heredity phenomena of organisms in plant and animal generation, which are reviewed here.<sup>1</sup>

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<sup>1</sup> A review of the full range of Gassendi's atomist scientific accounts is beyond the scope of this inquiry.

Just a sample of Gassendi's chemical and physical accounts illustrates the great range of applications he conceives for his atomist hypothesis. In addition to his suggestion that the four Aristotelian basic elements are kinds of molecular aggregates (q.v. chapter nine), some of his proposals include:

- i. *How vapors are created*: Liquids, like solids, are composed of atoms and void—the primary difference is that in the former case, more void separates the atoms. Heat atoms can take other sorts of atoms away from a liquid, which further increases the distance between the remaining ones; the result is atoms at an even greater remove from one another, which is manifested as vapors (*O I 398b–399a*).
- ii. *The solubility of silver and gold as a product of atomic make-up*: *Aqua regia* dissolves gold, and *aqua fortis* dissolves silver, as a result of their complementary atomic structures. Specifically, gold atoms fit the pores of *aqua regia* and silver atoms fit the pores of *aqua fortis* (*O II 33b ff., 39a–b*).
- iii. *An atomist theory of light*: Contrary to Descartes, light has nothing to do with pressure. Rather, it is a property carried by particular atoms (*atomi luciferae*) which are identical with heat atoms. These tend to travel at greater than average velocity because they generally have fewer obstacles in their paths (*O I 422a–432b*).
- iv. *A particulate account of sound*: Sound travels when the special sound particles travel. In contrast to a typical sound-wave view, the surrounding medium does not play an important role: Gassendi takes the velocity of sound particles, like that of light particles, to be invariant with respect to the air or wind in which they travel. In an experiment he models after a similar one of Mersenne's, he judges

1. *Attractive Forces*

A central characteristic of the mechanical philosophy is the effort to account for putative action-at-a-distance phenomena by viable mechanical explanations that refer only to contact action.<sup>2</sup> Some proponents of the mechanical philosophy are more insistent than others on this point, and Gassendi should be counted among the insistent. In his view, the phenomena to be so explained include not only actions caused by gravity and magnetism, but also those actions he says we typically attribute to occult properties, such as those apparently attracting and repelling through presentation of like and unlike qualities:

Sympathy and antipathy . . . though they may strike us with a certain stupor, are subsumed under the general ways of action and endurance [*patiendi*] which rule all natural things. These ways entail that there are no effects without causes, no causes acting without movement, no causes acting on objects at a distance—that is, to which such a cause is not present itself or through a part [*organum*] serving to conjoin them or transmit the object—so that consequently nothing moves anything else except by touching it or by a corporeal part touching it. From which it follows that when we say two things mutually attract and attach to each other by sympathy, or repel and separate each other by antipathy, we must understand that these things occur as in other bodies, with no other sensible difference than what holds for the subtlety and coarseness of the parts.<sup>3</sup>

This may be viewed as the hard case for devising materialist or mechanical explanations, given that Gassendi views sympathy and antipathy as plausibly having psychological or even social effects. By contrast, the attraction and attachment phenomena of gravity and magnetism should be easier to characterize in terms of interactions of atoms, since at least the objects of such powers of attraction (*vis attrahendi*) are always, and uncontroversially, composed of matter. In Section I, Book V of the *Physics*, he tries to explain both gravity and magnetism as the attraction of one body A by another body B in virtue of chains of atoms which emanate from B and pull A towards

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the velocity of sound to be 1,473 ft/sec [478 meters/sec] (his calculations are off by 435 ft/sec [146.7 meters/sec]) and invariant to the pitch of the sound (*O* I 418a–419a).

<sup>2</sup> Recent accounts of action-at-a-distance as discussed in early modern thought include Hesse (1961), Westfall (1971), and Pyle (1995).

<sup>3</sup> *O* I 450a.

it. The atoms which bring about magnetism and gravity are of the same slight size as those which give living things the capacity for sensation, and through their like sensitivity, magnetic or gravitational atoms may 'retrieve' those objects which have separated from the Earth. In his focused discussion of magnetic attraction, Gassendi suggests a parallel with the molecular aggregates of biological significance, where some collections of atoms are 'sensitive', in that they play the role of 'seeds' for organic compounds (more on the nature of such compounds in the following section):

... it seems that there is in the magnet and the iron a force analogous to the senses; and that the cause of this is the attraction of which we have spoken and which resembles what animals experience. . . . Like a sensible object, by the species or image it sends, turns towards it and attracts the soul which has the force to transport towards the sensible object a body of whatever thickness, so the magnet, in the way of the transmitted species, seems to turn towards it and attract the soul of the iron. . . . We would believe this with difficulty if experiment would not certify it—that a thing as slender as is the sensible soul (whether it is as the flower of the substance or a very fine breath, or whatever you will agree to) would be capable of transporting the mass as heavy and inert as that of a body. But then why not believe that there is in iron a soul or, certainly, at least something analogous to the soul? This something, however slender, can nevertheless transfer to the magnet the mass of iron, again, even if it is very heavy and inert.<sup>4</sup>

Spink takes the talk of souls here to indicate that this a 'hylopsychistic' account, and places Gassendi in the tradition of Maignan and Telesio.<sup>5</sup> Yet it is not entirely fair to think of these as 'psychist' views, for Gassendi never abandons his aim of developing mechanist accounts. Indeed, his account is very much in the materialist, contact action tradition of Epicurus and Lucretius.<sup>6</sup> Thus, what gives

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<sup>4</sup> *O* II 132a–b.

<sup>5</sup> Spink (1960), 94.

<sup>6</sup> In ancient thought, Galen promoted an influential action-at-a-distance account of magnetism (q.v. *On the Natural Faculties* [*De naturalibus facultatibus*], I, xiv; III, xv), according to which the lodestone attracts iron, per their sympathetic qualities. The primary ancient source for a contact action account was Lucretius, who developed Epicurus' view, suggesting that structural qualities of the lodestone and iron are responsible for their mutual attraction. In particular, atomic effluvia attach to the iron with hooks, in Epicurus' account (q.v. Galen, *Ibid.*, II, 44–52), and by vacuum action created by the lodestone's effluvia, in Lucretius' account (q.v. *RV* VI 906–1089).

Looking to early modern times and Gassendi's contemporaries, the foremost authority—as established through diverse experimentation—was Gilbert, who suggests

magnetic atoms (and, we will see below, gravity atoms) their ‘pull’ is not a spiritual force but a combination of mechanical features. These include the right kinds of protrusions, like hooks,<sup>7</sup> and configurations<sup>8</sup> which—positioned at the end of the chains emanating from the source body—enable those atoms to fasten to the

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that an attractive virtue or *vis* is effected by the emanation of magnetic ‘forms’ which endow lodestone (for Gilbert, the entirety of the terrestrial orb) and iron with a sort of order, presumably in bringing them together (q.v. *De Magnete: magneticisque corporibus, et de magno magnete tellure: physiologia noua, plurimis & argumentis, & experimentis demonstrata* (London: Petrus Short, 1600); Modern edition, *De Magnete*, trans. P. Fleury Mottelay (New York, Dover Publications, 1958), esp. 53–56). These forms were not Aristotelian in *sensu stricto*, as Mary Hesse points out, for although they endowed the attracted bodies with order, they were supposed by Gilbert to do so via efficient causation—rendering magnetic influence as a true action-at-a-distance (q.v. Hesse, 1960). Kepler followed suit, taking the magnetic virtue of the sun to act as a force pulling the planets around in their orbits (*Astronomia Nova de Motibus Stelle Martis ex Observationibus Tychois Brahe*, (Prague, 1609); trans. William H. Donahue (Cambridge; New York: Cambridge University Press, 1992)).

Other early modern speculation followed instead a contact action model, in the spirit of the mechanical philosophy. Proponents of such views included Descartes (whose well-known account in the *Principles* [IV, §147] centered on the varying directionality of screw-like particles—thus accounting for opposing charges), Kenelm Digby (*Two treatises: in the one of which, the nature of bodies; in the other, the nature of mans soule; is looked into: in way of discovery, of the immortality of reasonable soules* (Paris: Gilles Blaizot, 1644)), Christiaan Huygens (“Le Magnétisme”, in *Oeuvres complètes de Christiaan Huygens publiées par la Société Hollandaise des Sciences* (The Hague: Martinus Nijhoff, 1950), volume 19, 556–604), and Hobbes (*Elementorum philosophiae sectio prima de corpore* (London: A. Crook, 1655), XXVI 7). Such confidence in mechanical explanation was short-lived; accounts offered by Boyle (*Experiments and Notes about the Mechanical Production of Magnetism* (London: printed by E. Flesher for R. Davis, 1676)) and Hooke (*Lectures and Collections* (London: J. Martyn, Printer to the Royal Society, 1678)) noted that little is known of the actual manner in which magnetic phenomena are produced, even if in may be assumed that some mechanical account is fundamental.

Another early modern trend, emphasized sympathy as a basic quality of iron and lodestone, in the Galenic tradition. Thus, Bacon (*NO*, Aphorisms (Book Two) § XXV, XXXVI, XXXVII) spoke of ‘natural virtue’ drawing together attracted bodies, and Nicoleo Cabeus (*Philosophia Magnetica*, (Ferrari: Franciscum Succium, 1629)) offered a scholastic interpretation of magnetism as endowed in the qualities of bodies rather than Gilbertian Forms.

Much remains to explore regarding the early modern causal theories of magnetism; some valuable dedicated studies include Gordon Keith Chalmers, “The Lodestone and the Understanding of Matter in Seventeenth Century England”, *Philosophy of Science* 4 (1937) 1, 75–95; and Stephen Pumphrey, “Magnetical Philosophy and Astronomy, 1600–1650”, in *The General History of Astronomy*, ed. René Taton & Curtis Wilson (Cambridge; New York: Cambridge University Press, 1989), volume 2A, 45–53.

<sup>7</sup> O I 450a; O III (PGDA) 632a–b.

<sup>8</sup> Atoms come in all manner of configurations, as well as shapes, which accounts for their cohesion as ‘*moleculae*’; q.v. O I 271a–b.



‘attracted’ objects, plus the brute force of internal impetus which leads the atoms in one or another direction, and in so doing drags along the objects to which they are fastened.<sup>9</sup> What then, of Gassendi’s apparent attribution of a soul, or minimally, “something analogous to the soul”, to inanimate objects like the iron attracted by a magnet—can this be anything other than psychism? Yet it turns out that such talk of the ‘flower of the substance’ [*flos substantiae*] is a kind with his references to atoms as the ‘flower of matter’ [*flos materiae*]—by which he intends nothing spiritual. Rather, atoms or their aggregates are ‘flowers’ in the sense that the inherent mobility of matter’s basic elements lends all material objects their capacities for motion and change. Some atoms or combinations thereof may be especially active, individually realizing or jointly compiling such capacities so as to lend the bodies they constitute some characteristic we associate with the animate. It does not follow, though, that those constitutive atoms or aggregates are themselves animated, in the sense of living creatures, for they have no more than a tendency to motion (which itself is divinely endowed). Accordingly, the suggestion that magnetism works by one body attracting the ‘soul’ or ‘flower’ of another body amounts to the claim that such attractions are purely mechanical interactions of matter, where the magnetic matter is a bit more slender, subtle, and active than what it attracts. Rather than being an animist exception, this focus on properties of particulate size, shape, and interactions is wholly consonant with the orthodoxy of the mechanical philosophy (q.v. note 6).

In the gravity account his mechanism is even more perspicuous.<sup>10</sup> Gassendi’s broad interest in developing this account is to follow through with the Galilean program, and rebut the Aristotelian notion that a falling body seeks its proper place, namely, where the Earth

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<sup>9</sup> Partington (1961, volume 2, 465) compares this suggestion to Faraday’s proposal that polarized particles constitute lines of attractive force in a dielectric medium. Of course, Gassendi as a thoroughgoing atomist could not have accepted a medium or field of force which, as electromagnetic theory developed, turned out not to be particulate.

<sup>10</sup> Gassendi is convinced of the need for a mechanical and atomist account of gravity even before he has an adequate macro-level grasp of how gravitational phenomena work. In *De Motu* he proposes that, in addition to gravity, a downward force impressed by atmospheric pressure—instigated by the attraction from corpuscular streams—is necessary for accelerating the motion of bodies in free fall; see note 17.

is.<sup>11</sup> The ‘proper’ place, Gassendi asserts, is just wherever the body happens to be. Hence what a falling body ‘seeks’ is whatever body towards which it falls. Its motion in the case of bodies falling to Earth is contingently downwards but—as per his principle of inertia—otherwise akin to rectilinear motion in any other direction. The con-

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<sup>11</sup> The context for Gassendi’s gravity account is as rich as the entire Galilean tradition, along with the views of its detractors; q.v. Dugas (1958), Westfall (1971), and Ronald J. Overmann, “Theories of Gravity in the Seventeenth Century” (Ph. D. Diss., Indiana University, 1974). Whereas Galileo does not himself offer a *causal* account, a range of such views is developed in the early modern period; q.v. E.J. Aiton, “The Cartesian Theory of Gravity”, *Annals of Science* 15 (1959), 27–49, and H.A.M. Snelders, “Christian Huygens and Newton’s Theory of Gravitation”, *Notes and Records of the Royal Society of London* 43 (1989), 209–222, and Pyle (1995). Many of these views are mechanical in nature, employing the basic notion of corpuscles being pulled downward—though they diverge from Gassendi’s view that this takes place through a pulling of chains on the descending body. Thus, Descartes, Malebranche, and Huygens locate the source of gravitational pull in the action of vortices in the ether; q.v. Descartes, *Principia Philosophiae* (1644); Malebranche, *Recherche de la Vérité* (1675), and Huygens, *Discours de la cause de la pesanteur* (1693) (*Œuvres*, volume 19, 451–537)—recapitulating Huygens’ account of 1669 (*Œuvres*, volume 19, 628–645). Hobbes (*De Corpore* XXX 4–5) also develops a contact action theory somewhat more like Gassendi’s view, and reminiscent of the Lucretian theory of magnetism: voids created by the upward motion of bodies draw in air particles that then push those bodies downward in free fall; q.v. Cees Leijenhorst, *The Mechanization of Aristotelianism: The Late Aristotelian Setting of Thomas Hobbes’ Natural Philosophy*, Leiden: Brill, 2002, 190–191. (It is unclear, though, how this account is to be squared with Hobbes’ latter-day plenism.) Digby (1645) further develops the theme of particulate currents, suggesting that solar heat raises terrestrial vapors which drive a convection that returns to the earth as an ‘aetherial shower’ which builds pressure on bodies, giving us the impression of the phenomena of weight; Newton’s earliest views of gravity (1675) followed this model; q.v. Nicholas Kollerstrom, “The Path of Halley’s Comet, and Newton’s Late Apprehension of the Law of Gravity”, *Annals of Science* 56 (1999), 331–356. A curious variant of the particulate contact action theories is Hooke’s early proposal that the parts of all bodies (including the Earth as a whole) vibrate, in turn creating a radiating vibration in the ether that causes a ‘tendency towards the center’ which carries bodies down towards the earth; q.v. Hooke (1705/1969), 171, 183–185; and *Philosophical Experiments and Observations of the late eminent Dr. Robert Hooke*, trans. William Derham (London: printed by W.J. Innys, printers to the Royal Society, 1726; Reprint edition, London: Frank Cass Publications, 1967), 88; also Louise Diehl Patterson, “Hooke’s Gravitation Theory and its Influence on Newton. I: Hooke’s Gravitation Theory”, *Isis* 40 (1949) 4, 327–341.

Still other authors rejected the notion of gravity as an action of corpuscles in motion, instead suggesting that it is a quality inherent to bodies. For example, Roberval recommended that gravity be viewed as a natural inclination of bodies, whereas Bernard Frenicle de Bessy and Edmé Mariotte advised that gravity consisted in the mutual attraction of bodies; q.v. Huygens (1950), volume 19, 628–645; and Snelders (1989), 211. Ironically, Gassendi’s commitment to an inner principle of atomic motion brings him as close to these views as his picture of hooks and chains brings him to the other corpuscular action accounts of gravity. As elsewhere, the looming question is whether those two ends of his views can be seen as fitting together.

tingency in question is gravity, according to Gassendi, the cause of which is a dragging-down action of special particles (as per the magnetism account).<sup>12</sup> More specifically, rigid streams of atoms emanate from the Earth, and upon impact with objects above the Earth these atoms attach to those objects as they do in magnetic attraction—through hooks or other protrusions. Next, those streams draw in the objects towards the Earth. Gravity weakens proportionately to altitude, not because the strength of a force weakens over greater distances, but simply because fewer such streams of matter can reach the higher climes of the atmosphere.<sup>13</sup> The mechanical details here, as in the magnetism account, are problematic. For one, the *attachment* mechanism is not fully explained: the reliance on protrusions to fix together attracted and attracting bodies suggests that certain atomic shapes fit together so well and so quickly as to bond immediately and such as to avoid the rebounding behavior Gassendi expects whenever two solid bodies are thrust together. Yet the protrusions, after all, are as solid as any other facets of the atoms.<sup>14</sup> For another, the *attraction* mechanism is not fully explained; those atoms, once attached, should continue to move (upward, in the gravity case) or stay in place with the objects to which they are attached.<sup>15</sup>

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<sup>12</sup> *O I* 346a.

<sup>13</sup> Pyle sees Gassendi as anticipating the roots of the inverse square law, given that gravitational chains are emitted radially and the magnitude of its pull declines with distance (1995, 615). Pyle also follows Westfall in suggesting that a Galilean law of equal  $v$  for all falling bodies is inevitable where mass is proportional to weight (in the modern sense; in Gassendi's terminology, this is roughly equivalent to saying that force  $\propto$  mass). Gassendi writes:

... if two stones or two spheres of the same material, such as lead, one very small and the other one large, are dropped at the same time from the same height, they reach the earth at the same moment; and the very small one, even if it weighs no more than an ounce, arrives with no less velocity than the large one even though it weighs a hundred pounds and more. Clearly, the large one is attracted by more cables, but also has more particles to be attracted, so that the force and the mass are commensurate (*adeò ut fiat commensuratio inter vim, ac molem*), and in both cases it is as great in relation to each sphere as is required to complete the motion in the same time. (*O III* 495a; *B* 138).

Westfall (1971, 110) cautions, however, that not all atoms in a body may be assumed equal in mass, and it is not clear either that atoms attach to one another at one point only, or that the gravitational chains have constant tension.

<sup>14</sup> In Gassendi's view, whereas atoms bonding as a result of gravity or magnetism are thrown together, a more passive phenomenon is found in molecular cohesion which, while a sort of attraction, is produced simply by the happy configuration of atoms coming together.

<sup>15</sup> On this point q.v. Carla Rita Palmerino, "Infinite Degrees of Speed: Marin

Another sort of difficulty altogether—also shared by the magnetism and gravity accounts—is in explaining how singleton or even small groups of atoms might be thought to realize their attractive capacities. From what we observe of macro-sized bodies, attraction between two bodies of equal size is unproblematic. Yet on the micro-scale it is not apparent how two equally small groups of atoms might attract one another, mechanically speaking, for they simply might not have sufficient atoms to constitute the requisite chains.

Beyond their commonalities, one *difference* between the magnetism and gravity accounts is that the former is distinctly easier to harmonize with Gassendi's views about the internal weight of atoms than is the latter. In the case of magnetism, we typically take the attraction of a body to a magnet to entail outside causal influence, which is evident when we measure the weight of the body before and after it is attracted by the magnet. Since the body weighs more afterwards though apparently none of its other properties have changed, it must be something external to that body which causes the increase, and the best candidate for that external agent is the magnet; this much was plain to Gilbert and to most of his readers, Gassendi included. The account is completed for Gassendi by translating such talk about gross external causal influence on the macro-level into a corresponding micro-level appeal to the internal causal influence of atomic weight. In this instance, a weight change in the attracted macro-level body means that on the micro-level, atoms with their additional weight are super-added to the body, which is what his picture entails insofar as the special magnetic atoms attach themselves to the attracted body.

The gravity account, by contrast, cannot work this way according to Gassendi. He suggests there is no analogous increase in the weight of falling bodies because they move on their own and without any super-added weight.<sup>16</sup> It is hard to see how this might be

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Mersenne and the Debate over Galileo's Law of Free Fall", *Early Science and Medicine* 4 (1999), 269–328; esp. 301, Gad Freudenthal, "Clandestine Stoic Concepts in Mechanical Philosophy: the Problem of Electrical Attraction", in *Renaissance and Revolution: Humanists, Scholars, Craftsmen and Natural Philosophers in Early Modern Europe*, ed. J.V. Field & Frank A.J.L. James (Cambridge: Cambridge University Press, 1993), 161–172, and by the early commentator Jean-Baptiste de La Grange, *Les Principes de la philosophie, contre les nouveaux Philosophes Descartes, Rouhault, Regius, Gassendi, Le P. Maignan, etc.* (Paris: J. Couterot, 1681/1684), 192.

<sup>16</sup> O I 346b–347a.

so given that he takes gravity, like magnetism, to have an external causal influence on bodies. One might accept in the case of gravity directional influence alone—though this is not a view he proposes, and in any case that is not characteristic of the magnetism case (such that the two cases would be even farther apart). Another possibility is that gravity merely activates an already extant tendency of falling atoms to move—but this does not account for Gassendi's proposed dragging-down action of gravity. In *De Motu* he advances the view that both an external gravitational force and the internal weight of falling bodies account for their increasing rates of acceleration; that is, the rate increases because of a joint force comprising the dragging action on the part of the gravity-atoms and the inherent *pondus* found in the constituent atoms of the bodies. He subsequently corrects his calculations of the acceleration rate and determines that one element of the putative joint force—the weight of the falling body—suffices for his explanation, which is accordingly consistent with the Galilean account.<sup>17</sup> However, as we have seen, Gassendi retains a gravity account in the *Syntagma*, wherein special atoms feature a dragging-down action, in order to explain away the appearance of action-at-a-distance. In effect, he is offering at once two alternative causal accounts of the downward motion of falling bodies, and allowing expressly that one renders the other superfluous. As with the inertial motion account, Gassendi's commitment to an inherent atomic weight or motion creates more problems with the gravity account than it solves.

## 2. *Generation and Heredity*

However difficult it is for Gassendi to account for magnetic or gravitational phenomena on the basis of his dynamics and theory of matter, it should be considerably more complex to draw upon these

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<sup>17</sup> Specifically, the initial error in *De Motu* (O III 497a) is the suggestion that the distances traveled by bodies in free fall over equal times are in equal proportions (that is, by consecutive integers). In *De Proportione* (O III 621b) Gassendi acknowledges that Galileo's formulation—the law of odd numbers—is correct. On Gassendi's earlier error and later correction, q.v. Joseph T. Clark, "Pierre Gassendi and the Physics of Galileo", *Isis* 54 (1963), 352–70; Paolo Galluzzi, "Gassendi and l'Affaire Galilée of the Laws of Motion", in *Galileo in Context*, ed. Jürgen Renn (Cambridge: Cambridge University Press, 2002), 239–275; and Carla Rita Palmerino (1999).

elements of his physics to account for intricate *biological* or *physiological* systems, where even the macro-level phenomena (much less the underlying structures) are opaque to experience. Gassendi does not seem to recognize this difference, though—any more than other early moderns writing on biological features of the world—and happily proposes several atomist accounts of physiological and psychological behavior across a diverse range of organisms.<sup>18</sup> In the *Syntagma* he offers two tracts—*De ortu seu generatione plantarum* (Part II, Section Three (Prior), Book IV, Chapter 4) and *De generatione animalium* (Part II, Section Three (Posterior), Book IV)—which demonstrate his inter-

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<sup>18</sup> Some of Gassendi's atomist accounts of biological and psychological phenomena include:

- i. *Lunar moisture and organic growth*: Shellfish grow and marrow production increases during full moons because of increased humidity. This increase occurs when lunar moisture corpuscles are excited by sunlight, then transported to the Earth by rays from the sun reflected off the moon (*O I 450a–451a*).
- ii. *Animal behavior*: Gassendi echoes Lucretius's suggestion (*RN IV*) that lions avoid roosters at dawn because roosters can inject harmful corpuscles into the lions' eyes (*O I 453b–454a*). Sheep avoid unfamiliar wolves because wolves emit corpuscles of an odor offensive to sheep (*O I 456a*). Although he identifies shock at the sight of wolves as the product of simple fear (*O I 451b*), his human psychology relative to the passions—including fear—is also atomist at root (*O II 474 ff., 495 ff.*).
- iii. *Toxicology*: Electric rays (*torpedine*) stun persons by emitting corpuscles with a dulling power (*O I 454b–455a*). Natural poisons typically enter victim organisms by seeping through their pores, which is possible because of the tiny dimensions of their constituent particles. If those poisons can be cured by contact with elements of the attacking organism's body (for example, a scorpion or dog) it is because those particles can be reabsorbed by the attacker's body (*O I 455b*). Poisons which provoke strange behavior may work by producing activity in the victim sympathetic to activity of the attacker, which may be explained as chemical alterations the poisons bring about in the victim's sensory capacities and attunements. Thus people who are bitten by tarantulas dance around like tarantulas because poison particles passing through their systems recalibrate their hearing such that their physical responses to audio stimuli are similar to those of tarantulas—the victims are led by altered chemistry to move rhythmically with their attackers (*O I 456a*)!
- iv. *Cognitive faculties and attributes*: Gassendi rejects Lactantius's complaint that cognitive faculties and attributes like the 'senses, thought, memory, the mind, genius, [or] reason' cannot be built out of or be produced by atoms (Lactantius lodges this complaint against the materialism marking the classical atomist scenario). A viable atomist story, Gassendi maintains, may account for the senses and their functions though not the mind and reason (*O I 282b*). Thus, for example, we can explain memory loss as a physical change in the brain resulting from undernourishment; folds in brain matter preserve the physical embodiment of memory, but a deficiency in nutrition leads to the deterioration of those folds (*O II 406b–407b*). This attempt to explain memory in terms of the structure of brain tissue is close to Descartes's view in the *Treatise on Man* (*AT XI 177–178*).

est, if not his success, in addressing generation from a broadly materialist and specifically atomist viewpoint.<sup>19</sup> These discussions demonstrate as well that the complexity of such issues is indeed of another order of magnitude than is characteristic of the attractive forces issues, Gassendi's cheerful optimism notwithstanding.

In Gassendi's view, generation may be either spontaneous, emerging from elements in the earth, or non-spontaneous, emerging from parent organisms, generally by sexual means—and involving what might be called 'pre-organized' seminal matter (for reasons that will soon be clear).<sup>20</sup> In plants, both types of generation entail the development of a new organism from a single unfertilized seed which bears what he refers to as the 'soul' of the new plant. Such souls are composed of a material yet *spirit-like* substance which directs the division, differentiation, and development of the corpuscles in the growing seed. This ontogenetic pathway produces the same results regardless of whether the seeds arise by spontaneous or pre-organized generation (SG and PG, respectively). Two distinct processes may yield similar results because seeds composed of elements either from the earth or from other plants may share an identical corpuscular composition. Gassendi writes:

... nothing forbids our saying that atoms or corpuscles were created by God in the beginning and given a certain mass, shape, and motion, and that while these are being variously moved, and while they are meeting, interweaving, mingling, unrolling, uniting, and being fitted together, molecules—or small structures similar to molecules—are

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<sup>19</sup> The historical background and context for Gassendi's views of generation and heredity consists in the Aristotelian and Galenic traditions. Among the significant early modern investigators moving beyond those traditions, one must include Harvey, Malpighi, and among Gassendi's fellow mechanical philosophers, Descartes; q.v. François Duchesneau, *Les Modèles du Vivant de Descartes à Leibniz* (Paris: J. Vrin, 1998); Peter J. Bowler, "Preformation and Pre-existence in the Seventeenth Century: A Brief Analysis", *Journal of the History of Biology* 4 (1971) 2, 221–244; Jacques Roger, *Les Sciences de la Vie dans la Pensée Française au XVIII<sup>e</sup> Siècle* (Paris: Colin, 1963); Andrew Pyle, "Animal Generation and Mechanical Philosophy: Some Light on the Role of Biology in the Scientific Revolution", *Journal for the History and Philosophy of the Life Sciences* 9 (1987) 2, 225–254; and Saul Fisher, "Gassendi's Account of Generation and Heredity in Plants and Animals", *Perspectives on Science* 11 (2003) 4, 484–516.

<sup>20</sup> For Gassendi, spontaneous generation entails generation of organisms from molecular aggregates that are predisposed to grouping in ways that yield the structures of organisms. This picture of things differs considerably from a more traditional picture that has it that generation is possible from elements that do not even bear the features of organic building blocks.

created, from which the actual seeds are constructed and fashioned within the plant. In other words, the corpuscles which change into a seed within a plant are also attracted from the earth itself, and the only difference is that the fashioning of seeds can be more easily accomplished within a plant because of a more select supply of corpuscles or similar principles has already been produced and is now gathering. . . .<sup>21</sup>

Gassendi does not tell us, for either sort of generation, precisely how the right sorts of matter come together in just the appropriate configuration, nor does he specify the subsequent behavior of any plant seeds so configured. However, following his general views on molecular formation, it is reasonable to surmise that the seeds giving rise to plants are formed from just the right combinations of only those atoms that may compose vegetative matter. For in Gassendi's matter theory, there are classes of atomic aggregates that come together using only a fixed range of atoms—as per their physical compatibility or tendencies to combine.<sup>22</sup> As a consequence, seeds resulting in SG and PG alike should comprise the same atomic combinations, given that those combinations are governed by the same compatibilities and tendencies—and produce like new individuals.<sup>23</sup> Yet only the occurrence of SG would depend on the chances that requisite but otherwise independent components are sufficiently abundant at the right place and time, and that they tend towards the proper configurations. By contrast, the components of *semina* in non-

<sup>21</sup> O II 170b–171a; translation in *Marcello Malpighi and the Evolution of Embryology*, ed. and trans. Howard B. Adelman (Ithaca: Cornell University Press, 1966), 798.

<sup>22</sup> Cf. Bloch (1971), Henk Kubbinga, *L'histoire du concept de «molécule»* (Paris: Springer, 2002). Duchesneau (1998) and Osler, (2002) view the creation of atoms with dispositions to biological organization and function as a piece of teleology in Gassendi's theory; q.v. Duchesneau (1998) and Osler, "Gassendi and the Aristotelian Origin of Early Modern Physics", *Midwest Studies in Philosophy* 26 (2002), 167–184. (For Duchesneau (114) and Roger (1963, 136), that *semina* in SG require external impetus to start the process of self-organizing, suggests that Gassendi needs teleology to explain SG.) While Gassendi embraces final causation as a significant mode of explanation, in and out of biology (q.v. O III 360b–361a; Rochot (1944, 406); Duchesneau (1998, 96)), it is not clear that the divine endowment of atomic dispositions to organize as organic molecules counts as teleology, for it is not stated anywhere by Gassendi that such endowment (or any other) is done with any particular goal in mind (as, for example, to meet a divine goal of populating the world with organic bodies).

<sup>23</sup> Indeed, as Duchesneau (1998, 114) and Roger (1963, 138) note, if SG produces such new individuals as are comparable to those produced under PG, this is only possible altogether given the common nature of the atomic structures and attendant processes underlying all organic phenomena.



spontaneous generation have already been brought within proximity of one another, and fall into particular arrangements constitutive of *semina* by the time they constitute the characteristic seminal structures. In this sense, they are ‘pre-organized’. Accordingly, PG should occur with greater ease than SG, *mutatis mutandis*, because the proper atomic mix for generation is already present within existing plants. As Gassendi puts it, PG occurs more easily in plants than SG does, since “. . . a more select supply of corpuscles . . . has already been produced” in PG.

The distinction between PG and SG is not, in the end, richly detailed.<sup>24</sup> Yet Gassendi is clear in his view that PG accounts are more useful for generating biologically significant explanations than are SG accounts. One explanatory advantage to PG accounts over SG accounts is that only the former can tell us how a particular plant has a given set of traits as a consequence of any other plant having the same set. In other words, PG accounts can tell us about relations between individual plants and about inheritance phenomena, whereas SG accounts are rather more limited in what they can tell us about how a set of traits appears in a given plant. Gassendi draws this distinction by indicating that, as the product of parent organisms, only the seeds of PG bear the special vehicles of miniature souls that enable them to transmit their characteristics across generations and so allow for inheritance. Thus the contribution of the parent organism to the characteristics of the spawn is a function of the relation between two material souls: a soul spread thinly throughout a plant’s structure and generally animating the plant, and a miniature, material soul or *animula* in the seed which is part of the larger soul until the seed falls from the plant.<sup>25</sup> The role of the

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<sup>24</sup> This is a natural consequence of Gassendi’s view that a full account of why these processes unfold the way they do is unavailable to us, and can be known only to God (*O* II 266b–267a, 274b; Duchesneau (1998), 109).

<sup>25</sup> Like the larger soul of the parent organism, the *animula* has an atomic composition. In addition to the inherent motive force (that is, inner principle) found in all atoms, the molecular structure of *animulae* also features a special seminal force or virtue (*vis seminalis*) that guides development of the offspring (and is also found in crystals, guiding their uniform formation). The exact nature of this special force is left unclear, though it is apparently superadded to the inherent motive force (q.v. *O* II 170b–172a, 260a–b), arising in the aggregate, and not in the constituent atoms of the *animula* or seminal matter. Yet as Duchesneau (1998, 100–103) notes, Gassendi’s conception allows for a mechanical account of the *vis seminalis* as harnessing the motive force of the atoms in the *semina*, to organize and stimulate the development of the embryonic matter. An intriguing suggestion here is that, given that the *motion*

*animula* is to transmit ontogenetic information from parent to new plant, and it does this by receiving, in concentrated form, ‘ideas’ and ‘impressions’ from all parts of the soul of the parent plant, and communicating such information to the new organism which the seed produces.<sup>26</sup> Given the framework of Gassendi’s matter theory, we have here *micromerism*, an atomist version of the classic pangensis theory of Aristotle’s generation theory opponents.<sup>27</sup> One partic-

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of the *vis seminalis* is a function of those atoms’ motive force, different compositions of atomic weights should give rise to distinctive patterns of organic development, per the weight distributions among the embryo’s molecules.

<sup>26</sup> When the *animulae* combine in the new embryo—whether in plants or animals—they form a new, single *anima* that guides development of the new individual (*O* II 275a–b).

<sup>27</sup> A family of closely-related views, including pangensis, can be distinguished as follows: *Panspermism* is the global view that all new complex material bodies, organic or otherwise, originate in aggregates of seeds (*panspermia*) and the characteristic features of such new bodies are contained within those seeds which gave rise to them. Other views are more specific to biological phenomena. *Pangensis*, for example, suggests that seeds giving rise to individuals draw generative matter from parts throughout the parent’s body. *Defluxus* theory suggests that the parts of seminal matter flow from corresponding parts in the present organism. *Micromerism* (a term coined by Delage (1903)) is the view that the particulate units of which seeds are composed are atoms or combinations thereof, with special features or capacities that endow those seeds with a pangentic structure and function (q.v. Yves Delage, *L’Hérédité et les Grands Problèmes de la Biologie Générale*. (Paris: Schleicher frères, 1903); and S.J. Holmes, “Micromerism in Biological Theory”, *Isis* 39 (1948), 145–158). Significant non-atomist variations of such views among the ancients are found in Anaxagoras (q.v. Gregory Vlastos, “The Physical Theory of Anaxagoras”, *The Philosophical Review* 59 (1950), 31–57; and C.D.C. Reeve, “Anaxagoras’ Panspermism.” *Ancient Philosophy* 1 (1981), 89–108) and Hippocrates (q.v. *On Generation* § 3 and *On Diseases* §32, and Jacques Jouanna, *Hippocrate* (Paris: Fayard, 1995)). An atomist variation—and clear precursor of Gassendi’s view—is found in Democritus (q.v. Aëtius 3.6, A141, W.K.C. Guthrie, *A History of Greek Philosophy* (Cambridge: Cambridge University Press, 1969), II 467; and H. De Ley, “Pangensis versus Panspermia, Democritean Notes on Aristotle’s Generation of Animals”, *Hermes, Zeitschrift für Klassische Philologie* 108 (1980), 129–153).

Gassendi’s view of animal pangensis has it that representative elements from different parts of the body travel through the nervous and circulatory systems, reaching the male or female genital parts, where the *semina* are formed and these different elements combine to yield the *animula* (*O* II 270b–272b).

Roughly contemporary pangensis theories were developed by Claude Perrault (*De la Mécanique des Animaux (Essais de physique ou Recueil de plusieurs traités touchant les choses naturelles*, Volume III, 1680)) and John Ray (*The Wisdom of God*, 1692). The pangensis notion of one small biological element (in Gassendi’s picture, the *animula*) gathering and transmitting information from throughout the parent organism resembles the physical and chemical notion of *homeomerity*, or the representative mixture of all parts of a whole in the micro-structure of matter (Vlastos (1950) shows that the early homeomerism attributed to Anaxagoras explicitly embraces panspermism). Homeomeric mixtures were touted as holding the key to physical and chem-

ularly interesting suggestion here is his notion that the *animula* is partly ‘transfused’ from the root and accordingly may mimic the parent soul’s directions and guidelines for development.<sup>28</sup>

By contrast, Gassendi assigns no such analogous structure or process to SG seeds, and it is hard to see how they could acquire anything like the same soul or *animula* of PG seeds. Yet even if there were an *animula* in SG seeds, this miniature soul would not possibly have any relations to the soul of any parent plant, because there is no parent. While there are no such sources of directions, ‘ideas’, or ‘impressions’, Gassendi supposes anyway that SG seeds somehow also bear a similar sort of developmental or organizational information. What makes this possible—and what also makes it possible that the two modes of generation yield roughly equivalent products—is that the atomic compositions of each type of seed do not differ:

Hence when we have conceded that the seeds are equal, equal functions necessarily ensue from the equal dispositions we have assumed, that equal stamina are formed, and that equal plants arise from them . . .<sup>29</sup>

There is a hitch here: the seeds could not be equal in all respects, since the souls we find in PG seeds are related to their parent-souls, which guarantees some continuity across individuals—whereas nothing in SG does (there being no *animula*). It is conceivable in Gassendi’s model, that plants of the same species could develop from souls of either type—that “equal plants arise from them”—just in case the souls of PG seeds made a difference only for trait-inheritance and not for generation *per se*. By this token, equivalent characteristics might arise in plants whether or not they resemble those among members of previous generations; the distinction between resemblance relative to individuals and relative to species would thus collapse. But then on grounds of parsimony Gassendi need not have

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ical change by a number of iatrochemical writers and late Aristotelians who are Gassendi’s contemporaries, such as Daniel Sennert; q.v. Clericuzio (2000), Emily Michael (1997), and Ariew, *Descartes and the Last Scholastics* (Ithaca; London: Cornell University Press, 1999).

<sup>28</sup> Lest we lose sight of the fact that Gassendi is talking about a *material* soul of plants, here he proposes that an identifiable *piece* of the parent’s soul is responsible for development and is more pronounced in some parts of the organism than others are; q.v. *O* II 172b; Adelman (1966), 800.

<sup>29</sup> *O* II 173a; Adelman (1966), 801.

introduced a distinct mechanism for trait-inheritance altogether. In contrast to animal generation, he thinks plant generation is a relatively simple affair, and so perhaps in a tidier version of his theory SG alone might have sufficed. Having introduced *animulae*, though, he has proposed two very different generative processes, whatever similarities may obtain. Hence, while he might well reason that seeds involved in the processes *could* have ontogenetic pathways with equivalent outcomes (producing species-wise resemblance across individuals) given their common atomic compositions, it is not clear why he thinks such commonality alone *guarantees* such an equivalence. In the absence of the organizing *animula*, nothing about SG in Gassendi's model provides such a guarantee. Nonetheless, this model signals an advance over prior SG theories, which do not even offer a mechanism to guarantee resemblance relative to species. Gassendi's version of SG tells an atomist story as to how such resemblance is possible altogether.

Animal seeds (semen) also feature *animulae*. In a form of SG special to animals, one parent suffices, and the semen is created in the moment of generation.<sup>30</sup> In animal PG, by contrast, two parents are required and the two *semina* meet in the moment of generation. In both scenarios, the *semina* contain complete though folded-up and rudimentary forms of the animal offspring. Thus, in generation among animals, as among plants, new souls contain a plan for development. What is different, though, is the idea—typically associated with preformationism—that the mature physical characteristics of new individuals are somehow contained in premature forms found in the *semina*. In Gassendi's view, as the *semina* are created, their tissue matter is differentiated into familiar body parts of the mature fetus. He writes:

... the semen both is manifestly heterogeneous and consists of the same parts from which gradually and in one series the organic parts will be perfected. . . .<sup>31</sup>

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<sup>30</sup> As noted below, if one parent suffices to contribute the material and soul to a new individual offspring, this does not afford the opportunity to exchange traits from more than one parent. Moreover, Gassendi himself suggests that a fetus cannot even be formed without the exchange of seminal fluids. These two points lend an air of mystery to his notion as to how animal SG may work.

<sup>31</sup> *O II* 280b; Adelman (1966), 815.

One distinctive feature of this account is that Gassendi thinks that animal generation, much more than plant generation, requires sexual communication to ensure that progeny receive the requisite matter and genetic information. Following the Epicurean view, he suggests sexual generation involves the meeting of two seminal fluids and this meeting is solely responsible for the creation of new fetuses in PG. To the new fetus the semen of the two parents contribute the material tissue (equally) and the *animula*-soul (less than equally, we will see, as one contribution dominates the other). Given that this fetal soul is responsible for the development of traits in new individuals, the particular mix of traits in offspring results from the combinations of *animulae* borne by the two *semina* that meet in sexual reproduction.

The most unusual aspect of this view, though, is the proposal that, in addition to the two *animulae*, the semen from each parent contains its own new organism in miniature. Such a proposal appears to be a good candidate for a strong preformationism of a classic variety. Yet Gassendi's view does not quite fit this description. The argument for taking him to subscribe to a strong preformationism (Roger (1963), Bowler (1971), and Duchesneau (1998)) is centered on Gassendi's proposal that the new organism's soul—which directs the development of the seminal material from both parent organisms—itself comes from the parent organisms.<sup>32</sup> The notion is that a generation theory is preformationist if it entails that the organizing principle for the new individual exists intact in the parent organism prior to formation of the embryo. A 'classic' preformationist view further entails that an actual miniature, the features of which are less developed versions of the features of the new individual, exists prior to conception. This classic view clearly upholds a standard that Gassendi's theory cannot meet, given that the organizing principles his theory describes—the *animulae*—do not bear the physical traits of the new individuals. This would be true, obviously, of immaterial souls yet it is true of Gassendi's *animulae* as well, since they bear not the actual traits of the new individual but the organizational

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<sup>32</sup> Indeed, Duchesneau (1998, 114) suggests that, given Gassendi is a preformationist, he cannot accommodate a true SG since such generation cannot cull its seminal matter from any pre-existing body. Yet as we will see below, relative to PG, Gassendi is not a strong preformationist. Hence the lesson to be drawn here is rather that the epigenesis characteristic of Gassendi's SG is also characteristic (albeit along different lines) of his PG.

information (in physical form) which gives rise to those traits.<sup>33</sup> That the seminal matter *does* bear rudimentary forms of a new individual's traits must be considered irrelevant here since (a) the organizing principle is rather the distinctive *animulae* and (b) some selection and redistribution of parts from among the *semina* must occur in the creation of the embryo, given that not all parts come from any single parent, and that there is an excess of parts from the two *semina*. Putting such 'classic' preformationism aside, Gassendi could not have been a non-classical strong preformationist, either. The soul-like organizing principle contributed by one parent either makes the similar contribution from the other parent superfluous to the theory or else requires a theory of trait inheritance to explain how elements of the organizing principle from each parent make partial contributions to directing embryonic development.<sup>34</sup> In neither case do we see the robust determination of the offspring's traits by generative information, or actual traits, from a single source.

Instead, Gassendi offers a weak preformationism, according to which the parts of a new individual are brought together—under the direction of the two *animulae*—from among those parts of the miniatures extant in the two *semina*. This leaves the puzzle as to which semen the offspring will resemble, in what respects, and how the *animulae* direct such combinations. In short, a theory of inheritance is needed. Gassendi attempts to meet this need by explaining how dominance is achieved among inherited traits, and what characteristics of generation account for dominance relations. We might expect him, as a mechanist, to suggest that dominance results from

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<sup>33</sup> Bowler (1971, 228) and Roger (1963, 126–131) note that, for most generation theorists of Gassendi's era who also held that the parental soul gives rise to the soul of the offspring and guides its development, the new organism's soul was immaterial. These likeminded theorists included Fortunio Liceti (*De spontaneo viventium ortu. Libri quatuor in quibus de generatione animantium, quae vulgo ex putri exoriri dicuntur*, 1618), Aemylius Parisianus (*Aemylii Parisani . . . nobilium exercitationum libri duodecim de subtilitate . . . Accessit par et sanius iudicium, de seminis a toto proventu, ac de stigmatibus*, 1623–1643), Giuseppe degli Aromatari (*Epistola de generatione plantarum ex seminibus*, 1625), Nathaniel Highmore (*Exercitationes de generatione animalium*, 1651), and Honoré Fabri (*Tractatus duo, quorum prior est de plantis, et de generatione animalium, posterior de homine*, 1666). Gassendi—holding to his Epicurean tendencies—was alone among these writers in proposing a material soul.

<sup>34</sup> Bowler (1971, 228) makes a similar point relative to the 'classic' preformationist view, noting that the existing of a miniature in one parent makes the seminal contribution of the other parent pointless. The same superfluity should apply to any two-*semina* theory that is taken to be strongly preformationist in character.

physical interactions of tissues contributed by each parent's semen to the embryo. One could have it, for example, that bits of tissue from the two *semina* destroy, merge, or connect with one another so as to fashion particular mixtures of traits. Yet Gassendi thinks such physical interactions cannot account for dominance. He considers the scenario in which characteristics carried by each semen are joined in the fertilized embryo, and in which such a joining process entails the total physical dominance of one set of seminal tissue over the other, so that among those characteristics is the sex of the offspring. In this case, he suggests, we should expect that the male child would exactly resemble the father, and the female child would exactly resemble the mother. Here he assumes that all the characteristics carried by a particular semen would be linked—that there would be no exchange of traits by the parents. Whatever the physical interaction of the two sets of *semina*, the semen of one parent would contribute all the tissue matter of the new individual whereas that of the other parent would contribute none. However, Gassendi notes, that scenario cannot be accurate, because male children sometimes resemble their mothers and female children sometimes resemble their fathers. From this he reasons that the key cause of trait dominance cannot be the physical domination of the parts from one semen over those of the other. Moreover, he proposes—without further justification—that trait dominance cannot be decided *at all* by interactions between bits of tissue from distinct *semina*.<sup>35</sup>

Gassendi suggests, rather, that the key causes of dominance are sets of mental impressions that bear information about the characteristic traits of the parents. The individual offspring inherits a given set of traits from one parent instead of another because that set develops from a bundle of dominant impressions transmitted to the fetus. We may find broad parallels between these suggestions and the modern account of genetic dominance: for each offspring, there are two potential sources of developmental information, so there is a surplus of both information and its sources, hence a contest between

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<sup>35</sup> *O* II 284b; Adelman (1966), 815. This was not the only option open to Gassendi. In his view, each semen only contributes tissue matter to the fertilized embryo, whereas the development of particular characteristics in the new individual is directed by an *animula*-soul. Yet none of this blocks the possibility that, in the merger of under-differentiated tissue matter from each semen, physical interactions of that matter could help decide which traits are dominant.

the two sources of developmental information. Gassendi's story of this contest is of course quite different from the modern account, and potentially even more complex. He holds that every *animula* contains a 'précis' (*épitome*) of the corresponding parent soul, and the information each *animula* bears vies to direct development of the fetus. The contending bits of information consist of one parent's impressions of the other parent, such that the dominating information passed on by the parent with that impression produces in the offspring more traits of the viewed parent than of the viewer parent.<sup>36</sup> He writes:

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<sup>36</sup> Gassendi's role for parental impressions is in keeping with the long history, in science and medicine up through the modern era—and in medical traditions all around the world—of holding that maternal impressions may cause defects and diseases, as well as features of 'regular' development (q.v. J.W. Ballantyne, *Teratogenesis: an Inquiry into the Causes of Monstrosities. History of the Theories of the Past* (Edinburgh: Oliver and Boyd, 1897). Such impressions were even thought to be a possible cause of 'telegony', where offspring bear traits resembling those of partner prior to the actual father, the notion being that the mother forms a sufficiently powerful impression of the prior partner to affect the character of the future offspring.

Such theories of maternal impressions are found as early as the story of Jacob in the book of Genesis (30:25–39) and appear throughout Greek and Roman thought (including Empedocles, Plato, Aristotle, Pliny, Plutarch, Hippocrates, and Galen) as well as in Avicenna and a host of late Renaissance and early modern medical and scientific writers, including Agrippa (*De Occulta Philosophia*, 1533), Van Helmont (*De Injunctis Materialibus*, in the *Ortus Medicinae*, 1643), Paracelsus (31–32 (*Jacobi*); I/1 315, I/7 203 (Sudhoff & Mattiessen, *Sämtliche Werke*)), Sennert (*Épitome naturalis scientiae*, 1632), and Thomas Fienus (*De Viribus Imaginationis*, 1608). Other early modern writers arguing for maternal impressions included Henry More (*The Immortality of the Soul*, 1639), Montaigne ("On the Power of Imagination", 1572–74), Descartes (correspondence, *AT* I, 113; II, 20, 49, 241; *Traité de l'Homme*, XI, 176, *Passions de l'Âme*, XI, 177, 518, 538, 606), and Malebranche (1674, II 1 Ch. VII). Yet other authors defended the theory and reported putative cases up through the late nineteenth century.

The widespread appeal of maternal impressions theory, as Ross has noted, is undoubtedly due to its flexible nature, being variously explained by hylomorphist, materialist, and occult causal models; q.v. G. MacDonald Ross, "Occultism and Philosophy in the Seventeenth Century" (paper delivered at the Royal Institute of Philosophy, 1983). Among the early modern defenders of the theory, Fienus offers a particularly interesting antecedent to Gassendi's views, suggesting that maternal impressions shape the features of offspring when immaterial species of the imagination cause changes in the 'emotions' that are transmitted, via the humours, to the fetus (q.v. L.J. Rather, "Thomas Fienus' (1567–1631) Dialectical Investigation of the Imagination as Cause and Cure of Bodily Disease." *Bulletin of the History of Medicine* 41 (1967), 349–367). Gassendi's model partly resembles Fienus' hybrid of mental and physical causation (itself partly based on Galen's views). By adopting a physical notion of 'species', though, Gassendi offers a wholly materialist account of maternal impressions. In this he holds closely to the Lucretian and Epicurean concept of imaginative powers as simply one more feature of a thoroughly atomist model of physiological phenomena. A century later, materialist support for the theory



... it seems that commonly the force of the imagination [*vis Imaginationis*] must be applied... For the form of the image of an external object which has been impressed on the brain by the intervention of external sense and has moved the imaginative faculty residing in it seems so to set in motion the appetite and the spirits serving it, that the spirits themselves also retain a trace of the impression that has been made, and transport it with them through the body. Hence if the semen happens to be separating off, the spirits—which gather meanwhile and excite and variously pervade it—affect it [the semen] in accordance with their form (the whole mass of it and all its particles) and make them [the particles] partakers of their own impression; and thus while the particles are being suitably coordinated and are seeking their proper places in the fetus to be formed, they retain a trace of the impression or a resemblance to the image itself. It is therefore possible for either a male or female fetus to resemble the father if the imagination of the mother directed toward the father was more vehement [*vehementior*] and powerful than the imagination of the father; or conversely to resemble the mother if the imagination of the father directed toward the mother was more powerful than the imagination of the mother; or to resemble both parents promiscuously and confusedly if the imagination of both or of one directed toward the other was of about equal force; or to resemble neither parent at all if the imagination of both was distracted elsewhere and in the male did not have the female herself as its object and in the female did not have the male himself as object.<sup>37</sup>

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of maternal impressions fell apart as opponents such as James Blondel argued that no material causality was possible between the mother and the embryo—there was concern as well that no spiritual causality was possible, either.

Against this background, the distinguishing features of Gassendi's parental impressions theory are his integration of the atomist account of images with his overall heredity theory, and his allowance for paternal, and not just maternal, impressions. The Aristotelians, for their part, had good reason to propose that such influence had maternal origins only, thereby providing an outlet for expression of maternal traits that balances their theoretical commitments to the notion that the primary seminal contribution comes from the father. Insofar as Gassendi's theory is entirely non-Aristotelian, then, he has no need to strike such a balance, and is free to suggest that environmental factors affect fetal development through *both* parents' imaginations. On the other hand, even his weak preformationism does not easily square with the power of impressions from both parents, for such influence is superfluous if the embryo is preformed; indeed, at least one later opponent of maternal impressions tendered one argument on the basis of preformationism; q.v. Philip K. Wilson, "Out of Sight, Out of Mind?: The Daniel Turner-James Blondel Dispute Over the Power of the Maternal Imagination." *Annals of Science* 49 (1992), 63–85, esp. 76–78.

<sup>37</sup> O II 284b–285a; Adelmann (1966), 815–816. According to Gassendi, there are other parties besides the parents who may be ideally represented in the *animulae*: if one parent's impressions of, for example, a statue, is stronger than whatever the other parent's impressions, then the offspring will develop traits which match the impressions of the statue.

Gassendi does not suggest the nature of their struggle—specifically how such particles bearing information about one impression could contest another. He tells us that the stronger imagination from among the parents dominates, but such dominance as such cannot be transmitted. Instead, some medium must transmit to the *animulae* the relative strengths of the impressions. Although we are told little of the nature of that medium, it is undoubtedly just those impressions. Are such impressions material? While the *animulae* themselves are material, one could imagine that the bits of information they carry were not.<sup>38</sup> However, this is an instance where Gassendi's materialism is more thorough rather than less. In the passage cited here, he suggests that genetic information is carried by material impressions upon the *animulae*, just in the manner of his suggestion that folds and grooves in the brain are vestiges of neural activity from which we form memories. Yet none of this tells us how such impressions actually interact. Even with this account of the imagination's impressions as transmitted to *animulae*, we still lack a detailed explanation of dominance among inherited traits.<sup>39</sup>

Beyond his outlining an account of trait inheritance, the other principal novelty Gassendi brings to generation theory of his era is the suggestion of a 'force' which, special to *semina*, is the underlying and direct cause of development in the offspring. Like a number of other early modern philosophers—including Descartes and Malebranche—Gassendi offers a mechanist account of animal generation. Gassendi approaches Malebranche's view in combining this mechanism with a pre-existence theory of sorts, though he probably comes closer to Descartes in allowing that the definitive causal influence

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<sup>38</sup> While Gassendi holds that human beings also have immaterial souls, such are not equivalent with the *animulae*. As we will see below, the intricacies and puzzles arising from this dualism do not weigh upon his generation theory.

<sup>39</sup> Duchesneau (1998, 110) has noted that the process of trait inheritance is not fixed rigidly by pangenesis, given the crucial 'wild card' role of the parental imagination in determining traits of the offspring. Despite this randomizing factor, the process is nonetheless fixed in a broader mechanist sense. Gassendi's mechanical account of perception (and other cognitive faculties) allows him a seamless account of corporeal change resulting from mental impressions, consistent with his materialist mechanical philosophy. On the other hand, Gassendi's materialism is less easily reconciled with his additional proposal of a second, immaterial soul that is the seat of such higher-order cognitive capacities as abstract reasoning. That issue is addressed by, among others, Bloch (1971), Michael and Michael (1988, 1989), and LoLordo (2005a).

upon formation of the fetus is the genetic information carried by the embryo, entailing a combination of such information from the two *semina*. This view is *mechanist*, proposing that the development of new individuals results from interactions among atomic amalgams that constitute the *animulae* and tissue of the two *semina*. And it is a weak form of *preformationism*, allowing that plant seeds and animal semen contain in miniature, undeveloped form some or most of the actual physical characteristics of the maturing embryo, and ultimately, of the new individual. Yet—quite unlike the accounts offered by Descartes, Malebranche, or most other early modern generation theorists—his view has *vitalist* overtones, suggesting that there is a life-force (*virtus seminalis*) characteristic of only those aggregates of atoms that constitute *semina*.<sup>40</sup> What makes this sound like the latter-day doctrine of vitalism is that Gassendi's proposed life-force—vested in the *animulae*—enables semen or seeds to direct ontogenesis simply on the basis of what they contain at the inception of the new individual, that is, without the benefit of interactions with any other external matter. Naturally, this cannot be true vitalism since his account has it that all the relevant players are composed of atoms, not spirit-stuff. Further, in contrast to standard vitalist accounts, there is nothing emergent, strictly speaking, about the life-force Gassendi proposes. Like the bud to a tree, the life-force of the *animulae* is an offshoot of the parent organism's soul.

These various aspects of his account—so clearly in tension in their mature, doctrinal forms—somehow fit together in Gassendi's picture. His mechanism would be at odds with his talk of miniature souls if the latter were composed of soul-stuff. They are not, though, so there is no true conflict here—which assimilation to a wholly materialist account in turn makes it unreasonable to think of Gassendi as a true vitalist in any sense. His views about *animulae* would also sit poorly with his loose brand of preformationism if ontogenesis on his account did not require the organizing principle of the soul, but instead required only that the preformed tissue matter of *semina* naturally

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<sup>40</sup> As Pyle (1987) details, a range of other early modern generation theorists—including the Cambridge Platonists, late Scholastics, Boyle, and Malebranche—promoted causal factors that supplemented “pure” mechanist explanations of generation. But none of these other authors located their proposed additional causal features in particles constituting seminal matter which gives rise to the embryo from which the fetus is formed.

unfolded in the course of generation and development. Yet here, too, Gassendi's views are compatible given that the material *semina* are responsible for physical unfolding, and the souls associated with *semina* are responsible for developmental direction. In Gassendi's weak preformationist conception, an epigenetic-like development and refinement in the new organism follows the organizational principle established by the contributing seminal structures.<sup>41</sup> Prior to combining to form the embryo each semen contains tissue bearing characteristics of the parents, per his panspermist-preexistence view. However, it is only after the cross-fertilization producing the embryo that the tissue combined from each of the *semina* expands and becomes differentiated, directed and managed by the *animula*-soul. In this vein, Gassendi suggests the task of the *animula*-soul is to

... apply the given parts to parts... by replacing them in the position and in the arrangement with respect to one another [such] that they had to form a complete diminutive body.<sup>42</sup>

Gassendi's strategy for avoiding tensions in his view is to maintain a thoroughgoing materialist mechanism regarding the agents of generation, including tissue matter with the potential for developing into a mature new individual, the material soul which lays out the plan for this development, and the seminal force which—though apparently superadded to the net quantity of force in the world—nonetheless counts in his scheme as a mechanically viable causal feature of the world (made necessary by the *de novo* nature of offspring organisms).<sup>43</sup> It is not clear precisely how the different bits of matter

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<sup>41</sup> Bloch goes so far as to propose that Gassendi is a strong epigenesist, given the "perpetual changes" that the constant motion of organic molecules and their constituent atoms bring about as they yield the characteristic 'form' of life (q.v. Bloch (1971), 367). While epigenetic development clearly takes place in the Gassendist model, it is not clear that such development follows from these perpetual changes alone (that is, in virtue of the constancy of motion).

<sup>42</sup> *O* II 275b; Adelman (1966), 810.

<sup>43</sup> Descartes also offers a materialist mechanical account, but his is very different from Gassendi's. In the cartesian epigenetic account, each progressive development of tissue, organs, and systems in the new organism is the direct result of preceding mechanical interactions of those tissues that have already developed (or, in the case of the first tissues, those particles that are set in motion by the right environmental conditions pertaining in the womb). Q.v. Descartes, *La Description du Corps Humain* (*AT* XI); originally *La Formation du Fœtus* (published with *Traité de l'Homme*) (Paris: 1664); and discussion in Dennis Des Chene, *Spirits and Clocks* (Ithaca; London: Cornell University Press, 2001); Ali Bey Jedidi, *Les Fondements de la Biologie Cartésienne* (Paris: la Pensée universelle, 1991); and Gabriel Sanhueza, *La Pensée Biologique de*

must be related for generation to take place, or quite how the seminal force operates, and in the end, all Gassendi offers us is a gloss on what a viable account should look like. What is noteworthy about this gloss, however, is his insistence that any such account is viable only if it tells us how traits are inherited, and is told in terms of the motions and interactions of the smallest bits of matter, out of which the whole world—organic stuff or otherwise—is composed.

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The accounts of attractive forces and generation highlight three facets of Gassendi's program for atomist scientific explanation, only two of which are promising, and none of which is globally satisfactory. First, there is no natural phenomenon—including and especially biological phenomena—which is not within the purview of the programme. Second, wherever possible one should account for phenomena falling under that purview in terms of the relevant laws of motion. Third—as must have been frustratingly plain to Gassendi—a cost of this extended purview is an inability to live up to the program's empiricist aspirations and provide explanations that resolve rather than prolong or extend deep riddles about the subperceivable.

As regards the first facet, one of the most familiar aspects of Gassendi's atomist programme is his promotion of mechanical explanation of all physical and chemical phenomena in terms of the motion and other innate properties of atoms, and in accordance with the relevant laws of motion, and special forces (notably, *vis motrix*).<sup>44</sup>

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*Descartes dans ses Rapports avec la Philosophie Scolastique: le Cas Gomez Pereira*. Paris; Montréal: l'Harmattan, 1997.

Gaukroger adds an important reminder that, from a theological perspective, the cartesian fetus can only develop as a result of divine force—and not as a result of any force or power intrinsic to the body; q.v. “The Resources of a Mechanist Physiology and the Problem of Goal-Directed Processes”, in Gaukroger, Schuster & Sutton (2000), 383–400, esp. 387–388. In a physiological and natural scientific light, the matter developing from the cartesian fetus is as inert as all other matter, bears no special ‘intelligence’ regarding development, and is directed by no goals (except in the same sense that any other bits of matter have an ultimate cause in God; Gaukroger follows here a general assessment of cartesian force as divine outlined by Gueroult (1980) and Hatfield (1979)).

<sup>44</sup> Cf. Bloch (1971) and Palmerino (1998).

Indeed, given his emphasis on basic matter theory and molecular structure, it is tempting to see inorganic physical and chemical phenomena as a base case for Gassendi, with organic phenomena such as generation being a special case that requires ‘extra’ explanation, viz. in terms of *vis seminalis*. This picture of things is only reinforced by the Epicurean structure of the *Syntagma*, which moves from general physics, up to celestial bodies, back down to inanimate terrestrial bodies, and then finally to terrestrial living bodies. However, it is a mistake to read too much into the way Gassendi structures the *Syntagma*, precisely because he is simply following the Epicurean order. Far more telling is his suggestion, in the core explication of his atomist views, that the molecular structure of all bodies—which renders them organic or otherwise—is fixed at Creation, when God endows some atoms with properties that tend to facilitate certain sorts of combinations with other atoms.<sup>45</sup> Some such combinations are in effect organic molecules, in that they give rise to animate creatures. Others give rise to crystals or other forms of ‘inanimate growth’. Yet others form amalgamate inanimate bodies that do not feature growth. After Creation, though, the Divine hand plays no role here, and subsequent developmental phenomena occur according to the same laws and constraints governing all matter. In essence, the only difference between biological and non-biological phenomena for Gassendi is that the matter which sustains biological phenomena is simply endowed with distinctive properties at the beginning of the world. From his perspective, this is tantamount to establishing a unified programme intended to account for all matter and natural phenomena along the same atomist lines. The unified nature of this programme is nowhere clearer in Gassendi’s corpus than in his generation and heredity accounts, which appeal strictly to the matter theory, and its attendant laws and special forces, to explain emergence and development of the new individual and the inheritance of traits.

Regarding the second facet, Gassendi takes the notion of mechanical explanation via an atomist hypothesis to entail that physical accounts of atomic behavior should observe, or at least suggest a schema for observing, the relevant laws of motion. In particular, and Gassendi’s noninertial characterization of atomic motion notwith-

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<sup>45</sup> O I 281b (in response to Lactantius), 335b; q.v. Kubbinga (2002).

standing, his proposed magnetic or gravitational atoms *should* move inertially. Consider his report and explanation of the barometry experiments conducted by Pascal's brother-in-law at Puy-de-Dôme (described in chapter five). Gassendi proposes that the column of mercury in the experimental device rises at lower elevations because of greater atmospheric pressure. The pressure, in turn, he thinks is a consequence of greater gravitation acting on that portion of atmospheric air closer to sea level. According to his account, the overall downward pressure in what Pascal calls the 'sea of air' results ultimately from the pressure exerted by individual air particles that are dragged downwards by the force of gravitational atoms. Once the particles of air attach to the gravitational atoms, though, they no longer move as a result of their internal impetus alone but also as a result of interactions with other bodies, namely, those atoms dragging them downward. If the air particles should behave noninertially at this point, for example, under the causal influence of their internal impetuses, gravity in Gassendi's terms should not have the expected effect.

Further, consider the case where gravitational forces accelerate the motion of a body, as when rolling down an inclined plane. Gassendi is unable to explain this as a change in the features of the body's constituent atoms given that the weight (and so the motion) of atoms does not change under any circumstances. His account instead suggests that acceleration occurs because of the reeling-in action performed by gravitational or magnetic chains of atoms. However, this scenario also presupposes that atoms as well as supra-atomic bodies can pick up speed. As the amalgam of a body and those gravitational or magnetic atoms attached to it rolls downward, each element of the amalgam must be gaining speed *individually* since the rolling body never gains new constituent (gravitational or magnetic) atoms—rather, it simply attaches to them.<sup>46</sup> Conversely, under the influence of countervailing gravitational or magnetic forces, individual atoms should be able to decelerate, and perhaps lose all velocity,

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<sup>46</sup> In neither the case of magnetism nor of gravity could there be such a gain. In the former case, if there were, then the force of attraction from the originating source of the magnetism corpuscles would be correspondingly diminished—which would tend to prevent magnetic attractions underway from coming to fruition. In the latter case, if there were, then there would be a heightened resistance to acceleration from the newly-augmented mass of the body.

too. Thus it appears that atomic motion on Gassendi's account must be characterized in some instances as inertial—despite his stated views to the contrary—in order to sustain his corpuscular accounts of magnetism and gravity. This need for consistency with general dynamical principles such as those governing the inertial motion of bodies suggests that, whatever else he proposes in the way of non-inertial atomic behavior, his atomist programme for explanation must be pursued along standard mechanist lines if it is to be viable at all.<sup>47</sup>

As regards the third facet—Gassendi's empiricist aspirations for his atomist programme—his accounts of attractive forces and generation phenomena suggests that he is less interested in fulfilling those aspirations than his global empiricism might suggest. For although he may have thought there are feasible tests of the consequences of these various accounts, he never says what these should look like. For example, his contact action accounts *should* bear out if there are weight changes that correspond to the magnetic and gravitational phenomena we observe—but these are generally not changes he could have expected to be able to measure. In the case of his claims regarding inheritance, one might look to see if traits across related individuals correspond to the effects of the various mechanisms he postulates. Thus, one might test his heredity account by gauging the effect of sustained perceptual activity by parent organisms on the physical characteristics of their offspring. In this instance, however, the psychological phenomena may be concomitant with other, physically-based phenomena in, say, the seminal matter; the difficulty is in indicating those effects which by themselves require his proposed mechanisms over any others. At all events, Gassendi is not so much concerned with such tests that he bothers to describe any. It might be said that he lets his role as clarion for empiricism lapse here—though it is also possible that Gassendi did not take his charge to entail empirical demonstration of those phenomena. In the absence of satisfactory experimental design or measurements,<sup>48</sup> it would be sufficient (and sufficiently challenging) to generate merely plausible

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<sup>47</sup> This adherence is also further evidence that Gassendi intends his physics to be scalar invariant, for there would be no reason to think atoms should move inertially to begin with unless we took the relevant principle to govern the motion of all bodies independent of their size.

<sup>48</sup> Early modern atomists generally failed to devise adequate empirical tests of atomist accounts; q.v. Meinel (1988) and Lüthy (1996).



explanations of the attraction, generation, and heredity phenomena. Such plausible explanations would demonstrate the viability of subsuming accounts of natural phenomena under the global theory that matter is composed of atoms interacting mechanically so as to produce perceptually-accessible phenomena.<sup>49</sup>

Finally, the attractive forces and generation cases are two among many instances where Gassendi's atomist accounts of macro-level phenomena fail to escape the charge of *obscurum per obscurius*—explaining the mysterious by the more mysterious. The promise of his atomist ontology is that the special qualities he attributes to atoms or their aggregates—in this case the power of attraction or the capacity for bearing developmental information—should turn out to be more or less plausible as vehicles for mechanically effecting the macro-level phenomena he seeks to explain (the particular ontogenetic capacities he ascribes to seminal molecules no doubt landing on the distinctly *less* plausible side). Such special qualities do not deepen our understanding of the macro-level phenomena, though, because Gassendi simply states that some atoms or their aggregates bear those qualities while others do not. He provides no suggestion in the domain of natural philosophy as to how or why the micro-sized bodies come to have them, appealing only to the divine ordering at Creation.<sup>50</sup> This is precisely the charge of *ad hoc*, explanatorily impoverished ascription of qualities that Boyle later on brings against the Peripatetics and other iatrochemists—which charge he further considers relative to lesser variants of the corpuscularian hypothesis.<sup>51</sup>

How fair is this charge? Beyond their differential capacities to combine with other atoms, there are no other elemental differences

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<sup>49</sup> It is a further question, naturally, as to whether such accounts are plausible by Gassendi's own empiricist and mechanist standards; I identify these issues in chapter twelve.

<sup>50</sup> Occult qualities and supernaturalism in early modern science and philosophy have received much attention in recent years, spurred by the work of Keith Hutchison ("What Happened to Occult Qualities in the Scientific Revolution?", *Isis* 73 (1982), 233–253) and John Henry ("Occult Qualities and the Experimental Philosophy: Active Principles in Pre-Newtonian Matter Theory", *History of Science* 24 (1986), 335–381). One study focused on Gassendi is Osler (2001).

<sup>51</sup> One typical expression of Boyle's charge is this: "... for what is wont to be taught us of qualities in the Schools is so slight and ill-grounded that it may be doubted whether they have not rather obscured than illustrated the things they should have explicated." (*Origins of Forms and Qualities*, in *Selected Philosophical Papers of Robert Boyle*, ed. M.A. Stewart (Indianapolis, IN, Hackett Publishing Company, 1991), Preface, 13; q.v. Anstey (2000)).

among Gassendi's atoms outside of size, shape, and position. From that standpoint it does not make sense to look for distinctive fundamental features that might yield the varying and special qualities in question, unless such special qualities could arise from size, shape, or position alone.<sup>52</sup> In this vein, it is noteworthy that he proposes that the four (Aristotelian) or five (Paracelsan) elements may be composed of distinct sorts of atoms, suggesting that the basic qualities of the component atoms and their aggregates differ sufficiently as to undergird the variation among those elements that the Scholastics and iatrochemists consider fundamental.<sup>53</sup> This might seem a promising start for explaining the presence of complex properties of the elemental kinds or, for that matter, such complex properties of atomic aggregates as magnetic attraction or the capacity to bear ontogenetic information.<sup>54</sup> Yet in such instances Gassendi also fails to say why,

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<sup>52</sup> Indeed, the elemental differences that Gassendi proposes are enough to generate an 'incomprehensible' number of atoms of different sorts (*O I* 257a), which he takes to explain such differences of atomic origin among basic qualities such as cold and heat.

<sup>53</sup> Specifically, Gassendi proposes that atomic aggregates come together to fashion the 'false principles', including the Paracelsan active *tria prima* (mercury, sulphur, salt) and the two passive elements (earth and water); q.v. *O I* 399b–400a, *O III* (*Syntagma Philosophiae Epicuri*) 19a. These molecular seeds account for the stability of natural kinds; q.v. *O I* 472a; Hiroshi Hirai, *Le Concept de Semence dans les Théories de la Matière à la Renaissance: de Marsile Ficin à Pierre Gassendi* (Brepols: Turnhout, 2005). They also account for the transmutation of chemical composites; q.v. *O I* 141a–143a; Bloch (1971), 253–255; and Kubbinga (2002), 258–259. Whereas Bloch sees De Clave as the sole influence on Gassendi regarding the five principles, Hirai notes that other possible sources include Joseph Du Chesne (Quercetanus) and Guy de la Brosse.

<sup>54</sup> This would be along the lines of what T. Girill has identified as an 'Empedoclean' or 'manifestation' approach to explanation by appeal to micro-level parts ('micro-explanation') (q.v. "The Problem of Micro-Explanation", *PSA 1976* (1976) 1, 47–55). In this approach, the micro-parts of a macro-sized object have heterogeneous properties  $x: x_1, \dots, x_n$  across individuals in a coherent collection (e.g. the different parts of a living cell) and we account for macro-properties  $y: y_1, \dots, y_n$  in terms of those  $x_i$  manifest in some  $y_i$  because they predominate relative to that feature—and the properties are the same, independent of each (e.g. color). Girill proposes that the explanatory factor is not the mere repetition of the quality but the dominance phenomena among instances of the micro-properties. It is this heterogeneity and dominance to which Gassendi is appealing in his account of variation in special kinds of atomic aggregates.

Yet this is not the only sort of explanatory appeal Gassendi makes to atoms, which is consonant with Girill's suggestion that at root there are two kinds of micro-explanation. The second is a 'Democritean' approach, according to which the micro-parts of macro-sized objects have homogeneous properties  $x$  across individuals in a coherent collection (e.g. molecules of a given chemical compound), and we account

from the perspective of natural philosophy, particular atoms have the qualities he believes them to have.<sup>55</sup> And what of the one piece of a causal account that Gassendi provides in this regard, suggesting that in Creation God endows select atoms with distinct qualities, or the capacity to come together in such ways as would yield those qualities?<sup>56</sup> If Gassendi were right about the particular qualities God assigns to atoms and their aggregates, he would have at least identified some of the basic structural characteristics underlying the macro-level world, and suggested how an ontology encompassing only atoms and void could yield phenomena as diverse as gravity, animal generation, or the elemental kinds. He still would not have told us, however, without recourse to divine judgments and action, however, how those characteristics came to be features of the atoms which bear them, nor why they should be the basic ones as opposed to any others. In this respect he earns Boyle's criticisms of those chemical and iatrochemical theories that bestow on us one set of mysteries in lieu of another.

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for the macro properties  $y$  in terms of some  $y_i$  being reduced to some distinctive  $x_i$ , because the  $x_i$  in combination somehow give rise to the  $y_i$ —the properties clearly not being identical. This latter approach to explanation is enshrined in the classic primary/secondary qualities distinction, and as we have seen, such is a staple of Gassendi's explanatory accounts as well. However, as that distinction is deployed in the early modern era—by Gassendi, for one—it is inadequate to link these explanatory categories ('Empedoclean', 'Democritean') to an ontological distinction between micro-level parts that are heterogeneous or homogeneous (to be fair, Girill considers that latter distinction to be merely contextual). In particular, it is possible in Gassendi's atomism to have atomic features  $x$  that give rise to macro-level features  $y$  where  $x$  and  $y$  differ—so a reductive account is needed—yet  $x_i$  are heterogeneous across individuals. His atoms tend to heterogeneity, and this does not preclude their yielding differing features on the macro-scale. Such is certainly true of simple features like shape, but is also so of more complex features like motion which differs across atoms relative to  $v$ , and can yield altogether different  $v$  on the macro-level.

<sup>55</sup> Descartes employs in this regard a useful stratagem: for reasons stemming from our account of the natural world (viz. the inertness of matter), some phenomena cannot be explained in the context of natural philosophy, and must be accounted for by recourse to the divine (q.v. Gaukroger, 2000, 387–388). Gassendi appears to rely on a cousin of this principle, rooted not only in natural philosophy but in theology as well: if natural phenomena do not admit of an apparent scientific explanation based on the available empirical data, any viable account must be adequate by the light of reason (from a natural philosophical perspective) and by the concordats of faith (from a theological perspective).

<sup>56</sup> *O* I 281b (in response to Lactantius), 335b; *B* 401, 417.



## CHAPTER TWELVE

### ATOMISM, THE MECHANICAL PHILOSOPHY, AND EMPIRICAL VIABILITY

Does Gassendi's atomism have any novel character? This issue, which dominates much of the commentary on Gassendi, may be addressed by paying close attention to the fit of his atomism with a broader mechanical philosophy, and the empirical viability of his atomist hypothesis. One prominent view is that his atomism differs in relatively insignificant ways from that of the ancients, and numerous interpreters suggest the notable differences are those which Gassendi himself frequently stresses—the rejection of certain ancient claims on theological or doctrinal grounds, or what Margaret Osler has called the 'baptism' of Epicurean views. Yet Gassendi further distinguishes his atomism from its ancient sources by more detailed accounts of macrophysical phenomena such as the forces acting upon, and the manifest qualities of, macrophysical objects. His atomist accounts of magnetism and air pressure, for example, have no exact, detailed forerunners among the ancient atomist writings.<sup>1</sup>

It is also pertinent in this context to note Gassendi's rejection of Epicurus's views not simply on doctrinal grounds but in order to avoid untoward results for his physics or cosmology (which was theologically-influenced though not doctrinal). Epicurus, for example, suggests there are infinitely many atoms in infinitely great space forever existing across infinite time, which view Gassendi rejects on doctrinal grounds.<sup>2</sup> However, Gassendi also cannot accept this

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<sup>1</sup> Some ancient works provide important steps towards Gassendi's novel atomist accounts, though. Thus, one likely source for Gassendi's reasoning regarding the void in his barometric account is Hero's account of the vacuum, and the rudimentary mechanism for Gassendi's atomist account of magnetism is found in the Lucretian or Democritean accounts of attractive forces.

<sup>2</sup> It is not clear that Gassendi's doctrinal grounds regarding this issue were widely accepted. After all, a number of contemporary authors promoted some form of infinitism without meeting the Church's criticism. The notion that God might create infinite worlds was licensed by the 1277 condemnation of the Aristotelian denial of the possibility of creating multiple worlds. Bruno may have been burned at the

Epicurean view because if there were infinitely many atoms, then things might be as they are naturally and without any need for God's providence—since eventually infinitely many atoms acting on their own might yield the structures and relations familiar to us. Thus it is to preserve not doctrine but God's ultimate role in determining the outcome of bodily interactions that Gassendi rules out the possibility of an infinite universe and the infinitely many atoms that might inhabit it.<sup>3</sup>

Completely apart from modifying Epicurean claims, Gassendi crafts a novel atomism insofar as he tailors his views specifically to counter the competing matter theorists of his time, and in particular the premier non-atomist corpuscularian, Descartes. The part of cartesian matter theory which is most unacceptable to Gassendi is the plenist view that matter equals extension, such that there is no space not occupied by matter:

In our times appears the famous René Descartes, who considers the world as being neither finite nor infinite but indefinite, as is also in fact matter—which in the beginning occupied the entirety of space or, rather, was itself space (because he does not distinguish space from bodily extension, since he also admits no void at all), then would have been fragmented by God in a way to be resolved into tiny particles comparable to Empedocles' small fragments or Heraclitus' bits.<sup>4</sup>

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stake for holding such views, thought the Inquisition records are silent on the matter; q.v. Maurice A. Finocchiaro, "Philosophy versus Religion and Science versus Religion: the Trials of Bruno and Galileo", in *Giordano Bruno: Philosopher of the Renaissance*, ed. Hilary Gatti (Aldershot, UK; Burlington, VT: Ashgate, 2002); and F. Beretta, "Giordano Bruno e l'Inquisizione Romana. Considerazioni sul Processo", *Bruniana e Campanelliana* 7 (2001) 2, 15–50. The going concern in the seventeenth century was not whether God could create infinite worlds, though. Rather, the worry was over what the universe would be like were that *actually* the case, and the late Scholastics tended to demur on such claims; q.v. Edward Grant, *The Foundations of Modern Science in the Middle Ages: their Religious, Institutional, and Intellectual Contexts* (Cambridge; New York: Cambridge University Press, 1996); and Roger Ariew (1999), esp. 167–171.

<sup>3</sup> Q.v. his letters to Louis de Valois (Count of Alais) of October 24 and November 7, 1642 (*O* VI 158a, 159a). One result of this view is that the argument from design—if not for God's existence, then at least for God's particular role—requires a very specific design. Leibniz—who read Gassendi as well as Bruno—addressed such a difficulty by his principle of sufficient reason. He thereby guaranteed that, given infinite possible worlds, the world God created was in fact the best possible world, reflecting omniscience and providence at once.

<sup>4</sup> *O* I 257b–258a.

On the other hand, whether by charity or fault, Gassendi is less concerned with what marks cartesian corpuscles as different from his own. In particular, he insists that Descartes's smallest bits of matter, though they are not atoms, share the same mechanisms and features as Epicurean atoms:

... for these large bodies as well as for the smallest bodies found in nature, for all their qualities and for all the universe of phenomena, he [Descartes] requires nothing else in these fragmentary particles that what Epicurus requires of his atoms, nothing other than shape and movement under three small dimensions, with an appropriate position and order. . . .<sup>5</sup>

Indeed, Gassendi suggests in this context that the *only* feature of these corpuscles which distinguishes them from atoms is their further divisibility:

He refuses to call these little fragments atoms as well because they would themselves be divisible—and this neither in a limited manner nor to infinity, but indefinitely, as he *pretends* . . .<sup>6</sup>

To be sure, the presence or lack of a limit to matter's divisibility is the defining issue between atomist and anti-atomist corpuscularians. Hence Gassendi focuses on the cartesian proposal that there is no reason to think we cannot divide matter infinitely, and responds to Descartes as follows:

And for the rest, I ask you, while from such division and subdivision to infinity more and more parts are actually revealed, do you think that those that can be revealed are of some determinate number, or not? If you say that they are, there will not be a sufficient number to divide them to infinity. If [you say that] there are not, then there will actually be an infinite number of them. And certainly, how may the continuum not be exhausted, if they do not actually possess infinite parts, or indeed parts which, being infinite, render it [the continuum] inexhaustible? And, in fact, the parts that come from it by subtraction, do they become actually preexisting in it; otherwise, how could they have been subtracted from it? Thus those that remained from the subtraction, actually came to be, because otherwise they could not have been subtracted from it.<sup>7</sup>

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<sup>5</sup> O I 258a.

<sup>6</sup> O I 258a.

<sup>7</sup> AN 218a.

The merits of this response aside, this passage illustrates Gassendi's move beyond classical atomist arguments to independent reasons for thinking there are limits on matter's divisibility. This is not to suggest that he offers a thorough rebuttal or even assessment of cartesian anti-atomism; he glosses over significant differences concerning the capacity for motion among corpuscles, the overall nature of that motion, and its conservation. Yet his concern with and novel contributions to a debate over a paramount distinction among corpuscularians count against the view that his atomism is purely a 'baptized' Epicureanism. Rather, Gassendi is acutely aware of the competing contemporary matter theories, as well as historically significant ones,<sup>8</sup> and he intends his atomist hypothesis not so much as an historically-validated thesis (q.v. Jones and Brundell) or historically-competitive thesis (q.v. Joy), as a way of characterizing the physical world in keeping with the very scientific standards he helped to create. In particular, Gassendi intends that his atomist physics sustains standards of the mechanical philosophy and the new empiricism of the seventeenth century. This goal is attained, if at all, with variable success.

Gassendi's atomism is trivially consistent with several aspects of the mechanical philosophy—most obviously the ontological thesis (some form of corpuscularianism) and a methodological thesis governing the explanation of sensible qualities (by appeal to the qualities and states of micro-sized bodies). Yet as we have seen, his atomism is not clearly consistent with other aspects of the mechanical philosophy, most notably a meta-principle of scalar invariance, according to which our most general physical principles should describe the character and behavior of atomic and supra-atomic bodies alike. As I noted in chapter ten, such a meta-principle fails to govern the principle of inertia in that the constancy, acceleration, or deceleration of atomic motion in his view is completely independent of external impacts. This failure has the unhappy consequence that mechanical

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<sup>8</sup> Through his numerous friendships and scholarly relationships, Gassendi was exposed to the matter theories of, among others, Galileo (q.v. Pietro Redondi, *Galileo Heretic*, trans. Raymond Rosenthal (Princeton: Princeton University Press, 1987), and William R. Shea, "Galileo's Atomic Hypothesis," *Ambix* 17 (1970), 13–27), Étienne de Clave (q.v. Bernard Joly, "La Théorie des Cinq Éléments d'Étienne de Clave dans la Nouvelle Lumière Philosophique," *Corpus* 39 (2001), 9–44), Beeckman (q.v. Kubbinga, in *Société Scientifique* (1995), volume II, 283–302), Mersenne (q.v. Armand Beaulieu, "Lumière et Matière chez Mersenne", *XVII<sup>e</sup> Siècle* 136 (1982), 311–316), Fludd, and the Paracelsans (q.v. Clericuzio (2000)).



explanations of inertial motion on the macro-level ultimately appeal to accounts of noninertial micro-level motion. Had Gassendi provided a satisfactory account of emergence—which, we have seen, he does not—this might seem an acceptable result. This not being the case, a number of paradoxical results arise where the supra-atomic bodies in question are the least complex molecules, that is, small collections of atoms. Such bodies comprising multiple atoms are not bound by the same constraints as unitary atoms—which yields the perplexing state of affairs that two individual atoms may travel only at a fixed rate unless they happen to collide and adhere to one another, in which case their joint motion may either accelerate or decelerate. Even more perplexing is the scenario where they collide but do not adhere to one another: they must continue on at their original fixed rates.<sup>9</sup> Further, consider the case where two atoms are conjoined and traveling at velocity  $v$ . If they should come apart (spontaneously, for example), then the two parts of what was formerly an amalgam will split the measure of their conjoined weight (as might be expected)—and, as a consequence, their conjoined velocity. That is, one should continue to travel at some other velocity,  $x$  and the other at  $v-x$ . This is an incorrect result, though,<sup>10</sup> and such difficulties suggest that explanations of the motion and behavior of even larger, perceivable bodies by reference to the motion of atoms is equally ill-fated. To make such mechanical explanation work, Gassendi would have needed his laws of motion to be scalar invariant. This, however, would require abandoning his central view that atoms behave noninertially.

Another facet of the mechanical philosophy, I have proposed, is a commitment to such principles of motion as may yield—together

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<sup>9</sup> In terms analogous to the Galilean critique of Aristotelian free-fall, this puzzle amounts to how, in Gassendi's physics, two atoms traveling together are to 'know' whether to behave as two atoms singly or as a complex of two atoms.

<sup>10</sup> One might think that these sorts of cases should not arise: given Gassendi's view that heavier and lighter weights do not differ greatly in their rates of free fall, velocity cannot be covariant with weight (rather, acceleration of bodies in free fall varies with time, per Galileo; q.v. *O III (M)* 497a–b). This leaves open the option of suggesting that all atoms (no matter their other characteristics) should travel at the same, uniform rate. Yet this tack was not taken by Gassendi—and justifiably so. As he recognizes, there is a slight and even measurable difference in rates of objects in free fall, and while this does not tell us much about their relative weights, nor should it tell us anything about rates of atomic motion. Further, given that weight *just is* the tendency to motion, measures of the two should be covariant.

with the relevant matter theory—a complete account of macro-level features of the world, rooted in the composition and behavior of the underlying micro-level structures. Gassendi shares this commitment, even if he fails in the end to lay out viable principles governing the motion of atoms. Owing to the idiosyncrasies of his atomism—in particular, his proposal that the force inherent to atoms is a direct result of their having mass—Gassendi stands out among the earlier mechanical philosophers in suggesting a dynamical characterization of bodily motion.<sup>11</sup> However, it is a characterization that he does not fully enunciate and which in any case is irreparably flawed. One feature of Gassendi's atoms, in contrast to corpuscles posited by other mechanical philosophers, is that they are not inert—and as a striking consequence of this view he is compelled to account for atomic motion in terms extending beyond mere geometric characterization (as is the case, for example, in Descartes's characterization of bodily motion). Beyond the kinematic accounts of matter in motion entailed by such principles as that describing inertial behavior, his atomism entails closely linked notions of mass and force. Force (*vis*) is the product of atomic weight, and the force of more than one atom joined together collectively yields the motive character of supra-atomic bodies.<sup>12</sup> At least on the atomic level, mass (which Gassendi conflates with weight) just is motion or the tendency to the same, so one might expect that those principles governing motion somehow could be rewritten as laws we would deem part of a dynamics. As we have seen, this would have disastrous results, for there is no coherent way to adapt a principle of inertia to accommodate mass as an inherent and unremovable feature of bodies. Nonetheless, Gassendi's physics, broadly considered, remains distinctive in attributing force to bodies as a product of their mass and thereby accommodating some dynamical characterization of matter in motion, albeit not a very serviceable one—and by no means the Newtonian concept. This aspect of his science of motion contrasts with much of

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<sup>11</sup> A traditional assessment is that the development of dynamics awaits the Newtonian development of a satisfactory force concept, in terms of mass (q.v. Gabbey (1971/1980), Westfall (1971)). Gassendi's force concept is clearly quite different, yet achieves a key conceptual breakthrough in its connection to mass. Is this sufficient though? In other respects, Gassendi's physics cannot count as dynamical, especially considering his views on motion globally, as regards its transmission and manifestation on the macro-level.

<sup>12</sup> *O I* 384a–b.

the physics of his day, which is guided by the notion that force is the province of God or, as Gary Hatfield suggests of the cartesian view, God himself.<sup>13</sup> Koyré and others have proposed, quite fairly, that Gassendi's physics is all the poorer for his lack of mathematical sophistication. For all that, his focus on the role of mass in atoms as their source of motion shows as rich a conceptual grasp of what physical accounts may tell us about motion on the micro-scale as that marking other early mechanical philosophies—including that of Descartes.

Among his peers and fellow mechanical philosophers, Gassendi plays a distinctive role in promoting empiricist standards to which all physical claims, including atomism, must be held. Whatever we know of the physical world is known only through the senses, and as such constitutes knowledge of appearances, rather than knowledge of the intimate or interior nature of things.<sup>14</sup> Yet time and again Gassendi draws on *a priori* reasoning and historically-based arguments to defend atomist claims. Thus, among the instances of his reasoning *a priori* are the suggestions that atoms constituting liquids must have smooth surfaces so that they may flow freely,<sup>15</sup> and that the diversity of material objects must result from constituent, elemental bits of matter because nothing comes from nothing.<sup>16</sup> How does he try to reconcile his resolute empiricism with such reasoning and claims about the unperceived? Issues to consider in this regard include the scope and nature of such *a priori* reasoning as Gassendi offers on behalf of atomist claims, the evidence experiments and observation generally—or microscopy in particular—might provide of the subvisible, and the extent to which his theory of signs supports the notion that the perceivable provides reliable insights into the unperceivable.

As concerns the first issue, while Gassendi leads us to principal atomist claims via *a priori* routes, there are important empiricist detours and means of confirmation at the end of that road. By way of contrast, cartesian physics remains resistant to revisability by

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<sup>13</sup> Hatfield (1979), 113–140.

<sup>14</sup> Q.v., for example, *O* III (*Disquisitio Metaphysica*) 312b–313a, *R* 186–9.

<sup>15</sup> *O* I 402–404.

<sup>16</sup> *O* I 232b; as Gassendi relates in great detail, such *nihil ex nihilo* reasoning appears throughout ancient sources, but here he follows Persius (whom he refers to as *Satyricus*): “[Gigni] de nihilo nihil; in nihilum nil posse reverti” (*Satires*, III.83–84). Another source is Lucretius (*RN* I, 162–226).

experiential knowledge—by dint of Descartes’s appeal to reason as the final stage of his method, and his overriding metaphysical commitments.<sup>17</sup> Thus, for example, as Suppes (1954) suggests, Descartes’s denial of action-at-a-distance comes as a consequence of *a priori* principles of motion, which prohibit change in the state of a body by any other means than collision. Further, given that bodily motion is inertial, bodies may act only on, or resist the actions of, other bodies by impact alone. Hence contact action is built into this physical picture as an *a priori* constraint imposed by general principles that are, for Descartes, independent of experience.

Gassendi’s view of contact action is close to Descartes’s, though their paths to a similar perspective diverge considerably. First, it is *not* Gassendi’s principles of motion that guarantees contact action (as with Descartes) so much as his atomism which, we have seen, is formulated independently of that principle (and may as well be inconsistent with it).<sup>18</sup> Second, the way atomism guarantees contact action is not a matter of constraints imposed by general *a priori* principles, even if the roots of his hypotheses are *a priori*. Gassendi holds that the motions of aggregate bodies are simply the aggregates of atomic motions (any void among the aggregates being inert) and nothing else accounts for change among bodies (of any size); hence there is only contact action among atoms. Such views about the nature of matter and motion are grounded in appeals to reason—or, in other cases, borrowed freely from Epicurus and other ancient authors. But no background *a priori* principles stand in the way of appealing to empirical evidence to suggest that these claims are wrong. Unlike Descartes—at least in the case of contact action, and on a broadly apriorist methodological plane—Gassendi thinks of his physical claims

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<sup>17</sup> As Garber suggests, the place for experimentation in Descartes’s deductive reasoning (per the *Method* through the *Discourse*) is prior to the deduction “. . . as a guide to the connections we seek in reasoning” (2001, 102). In later writings, too—notably in the *Principles*—Descartes maintains the primacy of reason over experience. On the other hand, recent scholarship also recognizes a strong, even dominating empirical component in cartesian physics; q.v. Desmond M. Clarke, *Descartes’ Philosophy of Science* (Manchester: Manchester University Press, 1982); and esp. Gaukroger, *Descartes’ System of Natural Philosophy* (Cambridge: Cambridge University Press, 2002).

<sup>18</sup> Insofar as Gassendi introduces a principle of inertia on the basis of a thought experiment with some element of appeal to experience, he does not see that principle as Descartes does—that is, either as a matter ineluctably determined by reason instead of experience, or as deduced from such higher-order principles as the immutability of God.

as hypotheses which are in principle testable by, if not initially derived from, experience.<sup>19</sup> Indeed, some of his atomist accounts at least hint at foundations in observational findings. For example, he accounts for the Earth's attractive powers by analogies with what he takes to be the contact-action behavior of magnets and their corpuscular emissions.<sup>20</sup>

Granting that Gassendi attempts to adduce what he thinks of as experimental and observational evidence for certain elements of his atomist programme, it may be fairly asked what evidence might count as empirical support for claims about atoms. One classic strategy in arguments for atomism, echoed in the seventeenth century, consisted in proving the existence of the void in order to demonstrate the discrete structure of matter. Along these lines, Gassendi proposes several experiments in the *Animadversiones* and the *Syntagma*—first suggested by Hero of Alexandria—to produce evidence of the void.<sup>21</sup> One principal experiment entails the use of a pneumatic bombard or pump to compress the volume of a set number of air particles, such that those particles have nowhere to go save the previously unoccupied space of interstitial void.<sup>22</sup> Assuming such experiments demonstrate the existence of the void, though, what does this show about the existence or character of atoms?

As Meinel (1988) notes, some early moderns like Basso, Van Goorle, and Descartes suggest such an approach would be pointless, on the grounds that there can be a corpuscularian structure to matter even if—indeed, especially if—there is a plenum. Yet their suggestion does not detract from the classic strategy, adopted by Gassendi, of arguing for atomism by demonstrating that an interparticulate void could exist. For if such a demonstration was taken to show that matter is discrete, then if *some* corpuscularian view were true, atomism would be true. I discuss relations between arguments for atoms and for the void further in chapter fourteen. In this context, though, what is

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<sup>19</sup> Descartes does not always operate on a broadly apriorist methodological plane, however. Indeed, it may be said of numerous cartesian hypotheses in optics and hydrostatics that he fully intends their testability by empirical means.

<sup>20</sup> *O* II 128a–135b.

<sup>21</sup> Gassendi cites the Epicurean view that the existence of motion demonstrates the existence of the void; q.v. *AN* Book I, 170; cf. 173 f., 424 f.; *O* I 194a–b, 198b–199a. Cf. Marie Boas, “Hero’s Pneumatica: A Study of Its Transmission and Influence”, in *Isis* 40 (1949) 1, 38–48.

<sup>22</sup> Q.v. Joy (1986) 188–189; Grant (1981), 97.

notable is Gassendi's adoption of this classic strategy in his attempts to support atomist claims by experimental means. In particular, he reasons in this way when reporting on the dissolution of alum in salt-saturated water, which he offers as a new version of an ancient experiment (reported by Aristotle) designed to show that there are interparticulate voids, and thereby, that matter comes in discrete particles.<sup>23</sup>

The experiment is as follows: if we take a vessel filled with loose ashes and an empty vessel of equal size, then—proponents of the void contend—each vessel will hold the same amount of water. The explanation of the void proponents is that the water enters into voids between the ash particles. What is wrong with this experiment, Aristotle suggests, is that it is absurd to suggest that the water and ash (or any two bodies) are in the same space at the same time—which is what must be the case if we do not assume to begin with that a void may exist. What is really wrong with this experiment, Francis Bacon counters, is that the reported results are implausible: each vessel, in fact, cannot hold the same amount of water, by a significant degree.<sup>24</sup> Gassendi attempts to refashion the experiment and demonstrate the existence of the void, on the basis of more plausible results: if we take one vessel of water saturated with salt and another without salt added, and try to dissolve alum in both, we find that the salt-saturated water dissolves alum just as well as non-salt-saturated water does. He concludes that there must be differently-shaped interparticulate voids, each of which is capable of receiving a particle of a corresponding shape. Thus salt particles, as cubes, are received by cube-shaped voids; alum particles, as octahedrons, are received by octahedron-shaped voids; and so forth.<sup>25</sup>

As Meinel points out, if the circumstances are controlled so that the phenomena the experiment produces consist only in filling such voids in just this way—so that nothing else is occurring—then the volume of the solutions as a whole should not change. Yet this will hardly produce a generalizable account. This limitation was noted early on by Morin, who protests that we would increase the volume

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<sup>23</sup> Aristotle, *Physics* 4.6 (213b21–22, 214b7–8).

<sup>24</sup> Bacon, *Sylva Sylvarum* (London: Printed by J. Haviland for William Lee, 1631), 1.34.

<sup>25</sup> *O I* 195b–196a.

simply by varying the added materials beyond alum. That suggests a class of experiments resembling Gassendi's (but with other materials dissolved) will not result in a consistent explanation of how adding any one volume to any other yields anything less than the two volumes added together. So much the worse for demonstrating the existence of interparticulate void, much less atoms, Morin concludes.<sup>26</sup> While on this particular charge Gassendi does not respond to Morin, he could easily meet such an objection by stipulating that the interparticulate voids, or at least some of them, have regular (that is, at least quasi-fixed) shapes. This scenario is possible and even likely, if the surrounding particles are joined in a stable fashion. Further, under a regular-shaped void scenario, and given the range of distinctive void shapes posited in his alum-dissolving experiment, it is possible to have differential rates of dissolution. Consequently, it is also possible to have differential volumes among distinct sorts of solutions, in accordance with the sorts of voids present in the different solutions. Indeed, this kind of response is consistent with Gassendi's molecularist views, for if there are molecules which persist through chemical reactions, voids enveloped by such molecular structures may have the requisite regular shapes.

In his writings on the transformation of metals Gassendi also hints at, though never fully develops, another sort of experimental reasoning that Boyle would later present as a means of demonstrating the unchanging character of matter's primary elements. If we can demonstrate that the constituents of compounds persist through chemical reactions, that line of reasoning goes, then those constituents must be unchanging by their nature—as we suppose elements of matter to be.<sup>27</sup> Such arguments are still qualitative in character; they stand in contrast, though, to Scholastic and Paracelsan alchemical traditions of explaining changes in a given substance as the result of change in Aristotelian forms.<sup>28</sup> Some early modern corpuscularians—

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<sup>26</sup> Q.v. *Defensio suae dissertationis de atomis & vacuo aduersus Petri Gassendi philosophiam Epicuream* (Paris: Pierre Menard, 1651), 58–62.

<sup>27</sup> Q.v. Boyle's distinction between stable and unstable corpuscular compounds, in *The Sceptical Chymist* (*Works* I 506); and Clericuzio (2000, 118, 130).

<sup>28</sup> The Scholastic and Paracelsan alchemists suggest that the introduction of a new form brings about new qualities. Hence they are concerned with whether the old forms of reactants disappear, and whether the new form comes from a heavenly bank of forms or else is 'educed' somehow from the potentiality of preexisting

including Sennert and, to an extent, even Gassendi—do not reject such traditional explanation as incompatible with accounts of substantial change in compounds by reference to contributions of constituent particles or their aggregates to the appearance of new qualities.<sup>29</sup> Accordingly, Sennert and others proposed that reports of such substantial changes serve as empirical evidence of atoms, given the supposition that only durable, indestructible atoms could persist through those changes.<sup>30</sup> Even granting that supposition, though, this view founders on the suggestion that persistence through a wide variety of reactions could suggest their indivisibility, too.

Yet Gassendi never quite arrives at this strategy of empirical argument. He suggests, for one, that metals are transformed by such natural causes as sunlight, and that metals have germinal or seedlike bases in virtue of which they undergo generation-like phenomena (and possibly transmutation). Further, these germinal bases have common corpuscular constituents so that all such transformations ultimately occur by the same process operating on the same molecular structures, whether by natural means or—if at all possible—by artifice.<sup>31</sup> However, while he shares an interest in the transmutation of metals with alchemists following Scholastic and Paracelsan traditions, he does not infer from such transmutations or any other like chemical reactions that the constituent elements of a compound must

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matter. Further, they are interested in what happens to the form of compounds in chemical analysis, and the source of new forms of whatever ‘parts’ emerge. Q.v. Emerton (1984) and Clericuzio (2000).

<sup>29</sup> Sennert thought of the two approaches as complementary, in the sense that atoms could be fixedly distinguished and assigned to special roles corresponding to the four Aristotelian substances; q.v. Clericuzio (2000) and Emily Michael (1997). Gassendi’s reinterpretation of Aristotelian elements in molecular, hence (ultimately) atomist, terms (q.v. *O I* 399a–400a, *O I* 472a) suggests that he does as well. On the other hand, Gassendi stresses that his atomist reinterpretation of such elements is part of a reductionist strategy, folding the results of the Scholastic and alchemical traditions into a more comprehensive and less obscure physical and chemical account founded on atomist matter theory; q.v. *O I* 245b.

<sup>30</sup> Q.v. Clericuzio (2000) and Emily Michael (1997). Sennert’s blend of corpuscularian matter theory and the alchemical tradition is inflected in Boyle, too; q.v. William R. Newman, “Experimental Corpuscular Theory in Aristotelian Alchemy: From Geber to Sennert”, in Lüthy, Newman & Murdoch (eds.) (2001), 291–329; and “The Alchemical Sources of Robert Boyle’s Corpuscular Philosophy”, *Annals of Science* 53 (1996), 567–585.

<sup>31</sup> *O II* 140a, *O II* 142b (. . . sicque germen auri nihil aliud facit inter manus artificis, quàm quod facturum fuisset in visceribus Terrae.).



persist unchanged.<sup>32</sup> The closest he comes to this is the claim that corpuscles surrounding and containing interparticulate voids are structured in sufficiently stable formations that they are unchanged even when the voids are filled, for example, by the dissolution of salts.<sup>33</sup> This is to assert the stability of molecular aggregates, however, and not the unchanging character of the atoms themselves.

If directly perceivable physical and chemical phenomena do not yield strong empirical evidence for atomist claims, perhaps more or greater evidence is to be adduced from peering into the subvisible realm through a microscope. Gassendi himself had little direct experience with microscopes, save for early prototypes to which he was exposed through Peiresc.<sup>34</sup> As an observer of the skies, though, he was very much aware of the magnifying effects of telescopes, and he links the two instruments by suggesting that both may help us narrow the gap between what is visible in principle and what is currently not visible.<sup>35</sup> Accordingly, he proposes, what we can see through microscopes constitutes empirical evidence for beliefs about the sub-perceivable.<sup>36</sup> Thus, Gassendi suggests, we may be able to roughly judge, though not to exactly measure, the size of the smallest particles from microscopic observations.<sup>37</sup>

I return to Gassendi's enthusiasm for, and adventures in, microscopy in chapter fourteen. Here I note the difficulty that proposing what we see in microscopes yields empirical evidence for atomism depends on the claim that what we see there—the structures and processes of the microscopic world—genuinely resembles and operates similarly to what we see in the macroscopic world. Gassendi is in good

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<sup>32</sup> He even distinguishes between the possibilities of resolving compounds to their molecular and atomic bases; q.v. *O* I 479a.

<sup>33</sup> *O* I 195b.

<sup>34</sup> Q.v. *O* V (*De Vita Peireskii*) 290b, 306a, 319a; *VP* 158, 198–9, 234; and Lüthy (1995). Gassendi's work with microscopy precedes that of the early modern masters—q.v. van Leeuwenhoek (1715/1722); Swammerdam (1669); Hooke (1665); Grew (1682); and Malpighi (1686). On the other hand, microscopes had already entered into limited scientific use starting with Galileo. In the *Dioptrique* (1637), Descartes—whom Gassendi rebukes for not seeing the underlying and constant properties of wax with a microscope (*O* III (*DM*) 355a)—describes not only a simple microscope, but also a predecessor (never built) to the compound microscope.

<sup>35</sup> *O* III (*AM*) 456b–457b.

<sup>36</sup> As Meinel (1988) and Lüthy (1995, 275–291) note, Henry Power also promotes such a strategy for empirically demonstrating atomist claims; q.v. Power (1664).

<sup>37</sup> *O* I 268b–269a; q.v. *AN* I 207.

company in his enthusiastic embrace of this resemblance and similarity. It cannot be too great an empiricist triumph, though, for the viability of the resemblance and similarity claim depends on what we take microscopic data to represent—which is not necessarily an empirical matter. Such data may be reliably produced by genuine and consistent amplification of sensory capabilities (although the simple microscopes available to Gassendi would have been among the cruder and less reliable of such early instruments). If so, our notions as to how microscopes work—based, for example, on our understanding of the laws of refraction—permit our agreement regarding observation of images which are magnified to a particular degree and which, as magnified images, have particular distinguishing features (for example, a narrow band of gray, three rounds spots, or a certain crystalline form).

However, such agreement does not entail that the observational data constitute empirical evidence of those phenomena or entities we claim to see through the microscope. Without additional evidence to suggest the accuracy of such representations—a warranted mapping of the microscopic data to what the data are said to represent—what we see through microscopes is strictly an interpretive matter.<sup>38</sup> To compound the challenge, for such a mapping to be warranted for Gassendi, the evidence in its favor should be empirical in origin. In the absence of such evidence, interpretations of the data are perforce rooted in *a priori* commitments, including the observer's working physical hypotheses regarding the micro-structure of matter. Gassendi thinks we have good empirical evidence to suggest the regularity of the amplifying powers of microscopes (see chapter three) but he offers no evidence to suggest his particular interpretations of his microscopical observations. As we see below and in chapter fourteen, the view that such observations provide evidence of atoms and their behavior may be measured, from Gassendi's perspective, against the possibility that his working hypotheses about matter's ultimate structure suggest fruitful interpretations of the data. Some such

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<sup>38</sup> On the seventeenth century debates over the sources and integrity of accurate representation through microscopy, q.v. Catherine Wilson, *The Invisible World: Early Modern Philosophy and the Invention of the Microscope* (Princeton: Princeton University Press, 1995) and Philippe Hamou, *La Mutation du Visible: Microscopes et Télescopes en Angleterre de Bacon à Hooke* (Villeneuve-d'Ascq: Presses Universitaires du Septentrion, 1999).

metric—rooted not in the data itself but in the value of its interpretation—is needed given that the evidence Gassendi thinks we obtain from microscopy is a mixture of what we know from the senses and from background theoretical commitments. Purely empirical criteria to which one might otherwise appeal are not even available. It is a further consequence of theoretical commitments playing such a role that the atomist claims he believes to be supported by that evidence are rather supported by a like mixture of the empirical and the *a priori*.

Indeed, as Gassendi and other early modern corpuscularians realized that no ‘pure’ empirical evidence with respect to atoms or their properties could be found, as long as such evidence is conceived to be attainable only through direct perceptual acquaintance. If all that is perceived directly are the phenomenal features of things, then there can be no direct perceptual acquaintance with those things which are subvisible (such as atoms) and so have no phenomenal features. One strategy for addressing this issue is based on a primary/secondary quality distinction, according to which the phenomenal features of a thing are produced by the enduring and underlying features of that thing or its constituent elements. As Meinel notes, a number of early modern atomists hold this distinction, suggesting that the enduring qualities are the ones atoms bear, and that it is in virtue of atoms contributing to the structure of a particular supra-atomic object that they also contribute to bringing about those secondary qualities we associate with that object.<sup>39</sup> This strategy, in short, recommends pursuing an experimental chemistry to further our grasp of the enduring qualities underlying the phenomenal ones, such that we might characterize atoms as fully as possible without the benefit of direct perceptual acquaintance.

Meinel refers to this strategy as ‘epistemological’, reflecting the attempt of early modern atomists to work around their insufficient

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<sup>39</sup> Bérigard (1643) proposes that a core of ‘natural’ or primary qualities distinguishes different kinds of atoms, and their aggregates yield ‘familiar’ or secondary qualities, and Basso (1621) proposes that there are primary through quaternary aggregates which persist through reactions. For his part, Jungius (1642) runs together the concepts of atom, element, and ‘pure substance’—though this does not by itself suggest that atoms have the kinds of primary qualities which yield secondary qualities; q.v. Meinel (1988). As we have seen, Gassendi’s views on molecular aggregates and phenomenal and enduring qualities (which Meinel does not discuss) are rather close to the views of Bérigard and Basso in this regard.

perceptual acquaintance with the objects they sought to describe. Ironically, though, such a strategy by itself lacks a key epistemic ingredient, namely, an identifiable inference mechanism or set of rules for warranting an account of those enduring qualities not perceived on the basis of data reflecting only the ephemeral qualities that are perceived. In brief, what is missing is a justificatory scheme—and this is where Gassendi provides the crucial supplement of his theory of sign-based inference. As we have seen (chapter two), this theory says that we are licensed in interpreting perceivable phenomena as indicative signs of subvisible phenomena just in case such interpretations (sign-assignments) are undeniable on pain of contradiction, or what Gassendi believes to be equivalent, satisfactory to reasonable persons. The theory of sign-based inference may well fail to justify characterizations of atomic qualities such as are based solely on information about supra-atomic phenomena. After all, if the signs are not read correctly or are not truly indicative at all—if, for example our senses fail to satisfy Gassendi's requirement that they serve as reliable guides to veridical belief—then there is no justification for interpreting the available evidence according to atomist lights. All the same, the theory of sign-based inference marks Gassendi's attempt—unmatched by any of his atomist contemporaries and little addressed by his other contemporaries—to say how we might ever warrant the connections we draw between those features of the world we perceive and those that we do not.

That Gassendi tenders such an effort—to produce warranted evidence from sensory data for atomist claims—helps put in perspective his ample classically-inspired *a priori* arguments on behalf of such claims. Contrary to much recent commentary, it cannot be quite accurate that Gassendi's elaborate displays of scholarly erudition constitute his foremost notion as to how to justify atomism, the extensive nature of those displays notwithstanding. For his part, Gassendi holds that such erudite and frequent appeals to classical thought further the historical cause of, most notably, Epicureanism and, as a result, the philosophical cause of associated doctrines. Yet this strategy does not entail the principle (sometimes attributed to Gassendi, at least as a background view) that the greater the provenance of a theory, the more likely it is to be correct, or closer to the truth.<sup>40</sup>

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<sup>40</sup> Q.v. Joy (1986), Osler (1994). This interpretation of Gassendi's 'historical' argu-

An even more curious issue is the relation of this effort to produce warranted evidence for a corpuscularian matter theory, and the empiricist tenet that sensory-derived knowledge tells us nothing about the inner natures of things. At first glance, this tenet may seem threatened by any putative sensory-based evidence for atomism. However, two points suggest Gassendi is in no danger of violating this aspect of empiricism. First, his theory of sign-based inference allows that there may be inner natures about which we cannot learn on the basis of what is perceptually available to us. These inner natures must lie not only beyond our senses but also beyond the reach of justified sensory-based inferences about the imperceptible. The truly unknowable inner natures include, for example, features of things to which we can have no access because we cannot even reason about them, on the basis of indicative signs or any other evidence or understanding of the same.<sup>41</sup> Other sorts of inner natures, though, might well be possible to learn about, even if they or their physical manifestations are imperceptible, on the basis of such inferences. Atoms and their features and behavior are primary

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ments accurately reflect his deep interest in argument rooted in the rhetorical tradition and his central project of rehabilitating Epicurean thought as an alternative to the still dominant Aristotelian frameworks of his day. However this interpretation is also not terribly charitable to Gassendi, suggesting that the origins and history of a given account yield or otherwise constitute reasons for subscribing to that account. Indeed, given his express desire to ‘cleanse’ Epicurean thought of its atheist elements, Gassendi’s attraction to those views was surely not rooted in their provenance. His pervasive rhetorical appeals to the history of thought—and the Epicurean framework in particular—seem more likely a part of a strategy that inverts recent interpretations: the theories (for example, of atomism) have a good chance of being correct, so on rhetorical grounds it is necessary or at least desirable to present their provenance, and relations to other classical views. This serves the rhetorical purposes of addressing an audience he believes to place profound weight on the opinions of great authors and on arguments that echo a tradition as worthy as that of the Aristotelian legacy.

The role of specifically *historical* argument is but one element in the broader question as to the nature of relations between Gassendi’s general *a priori* and empirical strategies for supporting his atomist claims.

<sup>41</sup> One possible instance in this regard is the nature of the origin of matter and its characteristics—a feature of creation about which we have no sensory evidence nor any other beliefs justified by sensory evidence. On this specific set of issues, Gassendi believes that he is compelled by doctrinal constraints to accept a particular viewpoint. Just to be sure, he also rejects a variety of alternative creation stories offered by classical authors, on the grounds that all of them are contrived from fantasy, that is, without the merit of being supported by Holy Scripture; q.v. *O* 480b–484b.

candidates for such explorations given the evidence Gassendi believes we can adduce towards adequately understanding them and their role in physical theory. Second, Gassendi never pretends that his atomist programme is anything other than hypothetical,<sup>42</sup> and that whatever claims we make about the inner nature of matter are further limited in that our finite powers of sensing and reasoning prevent us from fathoming either the ultimate mysteries of the natural world or the background theological parameters of any such claims:

... in all good faith we will attach ourselves to expose and explain what is presented to us as closer to the truth in the domain of nature's things but which, as such, we have no hope to discover in them the deepest recesses, nor even to not remain ever-remote from them—so confining us, full of admiration, to what is only sort of an entryway. We understand that nature is an immense and sacred temple in the sanctuary of which the Divinity dwells, spreading and putting into work His power and unextinguishable wisdom. But it is not granted to us, poor little men that we are, to access and penetrate them. It is permitted for us to reproduce, to a certain measure, some effects of the operations of nature. If, however, in some way our look becomes more penetrating, it is not less intensely remote from the depths where the secret and Divine power accomplishes his admirable works.<sup>43</sup>

Nonetheless, the book of Nature is no more than partly closed for Gassendi. He offers his atomism—empirically supported or otherwise—in the same spirit of utilitarian solace he bids us for the limitations we face in attaining profound knowledge of the world's inner constitution and workings:

I do not say this, certainly, to deter us from this sort of research and contemplation, since, as little as it may be that we can see clearly, that little is more precious than gold, and there is no occasion where we must heed more the counsel of the Poet who ends by this consideration:

*One may advance up to a certain point, though it is not given to go beyond.*

I draw attention to this counsel at this point only so that he who advances full of hope does not complain after having been injured, if, for lack of having penetrated everything more deeply, he finds anyway what he needs.<sup>44</sup>

<sup>42</sup> Q.v. for example, O I 485b.

<sup>43</sup> O I 132a (*Proemium* to the Physics).

<sup>44</sup> O I 132a (*Proemium* to the Physics). *Est aliquo prodire tenès, si non datur ultrà*, Horace, *Epistles* I. I. 32 (Horace actually writes “*Est quadam prodire tenès . . .*”).

This striking, utility-oriented outlook on physical theories might be taken to license lower expectations for Gassendi's atomism. For better or worse, many commentators on his thought have followed suit, viewing the main advance of Gassendi's atomism as a successful and thorough revival of an ancient doctrine. The error of such a gloss, which merely highlights Gassendi's talents as a historian, should be clear from what are (at a minimum) two novel contributions to early modern atomism: a special concern with force in the micro-structure of matter, and a genuine effort to grapple with the problem of justifying evidence from the senses for the subperceivable. Neither facet of his atomism was particularly successful except in highlighting problems to be addressed in subsequent matter theory and the methodology of understanding the micro-world. Yet his articulation of the problems remains, as always, a significant contribution.





PART IV

ATOMISM AS HYPOTHESIS AND  
AS EMPIRICAL KNOWLEDGE



## CHAPTER THIRTEEN

### ATOMISM AND SCIENTIFIC METHOD

I have endeavored to show that Gassendi's theories of empirical knowledge and scientific method are foundational to his defense of an atomist hypothesis. By contrast, one popular line of commentary suggests that the significance of that defense consists, not in drawing on those foundations, but in reintroducing ancient views of Epicurus and Democritus against a backdrop of the reigning Aristotelian metaphysics and the principal corpuscularian challenge of Descartes.<sup>1</sup> Yet Gassendi does not earn his place in the annals of physics (or philosophy) simply by reminding his contemporaries of a previously forgotten and ultimately incorrect doctrine. Rather, as we saw in chapter twelve, he is rightly considered among the first *modern* atomists because he attempts to mount this defense on at least partly empirical grounds. Unsurprisingly, perhaps, we also saw that his efforts in this regard are not entirely successful: he fails to produce any compelling experimental evidence for his atomism. Looking beyond the constraints and particulars of Gassendi's experimentation, one may further ask whether, to begin with, his proposed epistemological and methodological views indeed represented viable foundations for atomist claims. In this chapter and the one that follows, I explore two dimensions of the relations between his atomist hypothesis and theory of sensory-derived knowledge. First, I assess the fit of atomism with his notion of warranted and formalized empirical belief—in short, whether Gassendi's defense of his atomist hypothesis is exemplary of his scientific method. Next, in chapter fourteen, I explore the possibility that Gassendi draws too tight a connection between his arguments for atomism and his account of empirical knowledge, such that these views mutually rely upon one another so as to yield, jointly, a circle.

The fundamental role of Gassendi's epistemological and methodological views play relative to his atomist hypothesis emerges in the

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<sup>1</sup> This line of commentary includes Brundell (1987), Joy (1987), and Osler (1994).

application of his cherished empiricist strategies. He draws on the *regressus* method and on probabilist inference as means of building atomist claims upon sensory data, establishes evidentiary claims for atomism in light of his theory of signs, and utilizes inference to the best explanation as a mode of adjudicating among atomism and competing matter theories.<sup>2</sup> In relying on his theories of knowledge and method to direct his choice of matter theories and adumbrate his atomist claims, Gassendi follows a somewhat unusual path. He develops the general insight, common to empiricists of his time, that scientific knowledge requires transcending passive observation—in opposition to more doctrinaire empiricisms (such as Digby associates with ‘Adamism’, or as might be later associated with Berkeley).<sup>3</sup> The special mark of his empiricist natural philosophy, though, is his more nuanced view that scientific reasoning succeeds where it goes beyond observation and synthesis of reported data. Thus, he supports an atomist hypothesis by appealing to evidentiary claims inferred from indicative signs, believes that atomism has explanatory virtues because it accounts for evident phenomena, and holds that the atomist hypothesis is most probable because it offers the best explanation of the total empirical evidence, yielding the most likely account. These strategies may be construed as a retreat from empiricism altogether. Gassendi does not see matters in this way and instead suggests that they are rooted in empiricist tenets. By relying at least indirectly on empirically-attained data, each of these strategies counts for him as a piece of his programme for developing a physical theory on the basis of sensory information.

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<sup>2</sup> By contrast (as I have argued, in chapters nine, ten, and twelve), neither historicist interests nor theological concerns alone bring Gassendi to atomism—if indeed they play a pivotal role at all in this regard. Such interests and concerns are far more significant for Gassendi’s rhetorical expression, views on religion and polity, and perspectives on personal conduct; q.v. Sarasohn (1996), Taussig (2001).

<sup>3</sup> Advocates of experiment (Bacon) and augmenting our native optical grasp through magnification (Galileo and Kepler) stressed the necessity of not relying on the senses alone to capture empirical data. That scientific experiment required surpassing the limits of a strict and naïve empiricism would be obvious to all who accepted a primary/secondary qualities distinction, as recent commentators have noted; q.v. Martin Tamny (1986) and Harold I. Brown, “Empiricism”, in *Encyclopedia of the Scientific Revolution from Copernicus to Newton*, ed. Wilbur Applebaum (New York: Garland Publishing Company, 2000), 207–209. Gassendi goes a step further, proposing elements of a method that, he maintains, accommodates this insight yet reflects strong empiricist commitments.

Yet like much else in Gassendi's scientific *oeuvre*, the atomist arguments do not entirely conform to the proposed method—as can be seen in the fit of his matter theory with the *regressus demonstrativus* method he outlines in the *Logic*. There is no reason to think, for example, that the salient arguments for his core atomist claims can be laid out in such fashion that they manifest a search for the middle term—or that, through a sort of species-genus analysis, they may reveal the identity of any such middle term. For his part, Gassendi never explicitly proposes that his arguments for atomism should adhere closely to these elements of his method. Nonetheless, in the *Physics* he suggests that we should arrive at atomist claims in something very like the *regressus* fashion:

Our knowledge is subject to this condition: we cannot penetrate the inner nature of things, even though we can know some of their effects. We must therefore take ourselves to be satisfied if, having divined something of these natures from the occasion of some effects, we may attempt to accommodate to other effects the notions we have accepted concerning their natures—whatever those notions could be—when we wonder about the causes of things, or search how they have their origin in the natures proper to them.<sup>4</sup>

Here Gassendi echoes his proposal in the *Logic* that we reason from effects to causes, thereby 'divining something of these natures', and then try to identify how those natures could produce other effects. In the present case, the suggestion is that it is possible to infer the behavior and character of atoms from the surface-level phenomena we take them to produce, and then to indicate how such atomic phenomena might bring about other effects on the supra-atomic level. In fact, however, much of Gassendi's atomist reasoning departs substantially from this suggested path. Broadly, his approach in the *Physics* is to propose what atoms should look like—typically, by way of *a priori* assumption—and then see if such a model adequately accounts for the phenomena of bodies which atoms compose. Along the way, he provides numerous elements of what he takes to be empirically-derived evidence on behalf of his atomist programme. It is by no means the general case, though, that his starting point for global investigations into the ultimate constituents of matter is inferring the nature of atoms from the surface-level phenomena, as one

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<sup>4</sup> O I 207b.

might expect from a *regressus* prescription. His appeal to effects as manifest in experience—at least in the *Syntagma* framework—instead follows his enunciation of a reasonable working hypothesis.<sup>5</sup> In this sense, given Gassendi's expectations for *regressus* method, he fails to realize them in his atomist explorations.<sup>6</sup>

On the other hand, Gassendi's arguments for atomism closely conform with a different part of his method, the probabilist conception of viable inference or 'logic' in scientific reasoning. This conformity is independent of whether, in arguing for atomist claims, he derives premises for those arguments from experience or reason. *All* such arguments are probabilistic in his view, because the claims on which they are premised—including those apparently rooted in reason—are in turn based on sensory-derived ideas, hence less than certain. This much is a trivial result of his commitment to the empirical origins of knowledge. There are some exceptions to that empiricist rule, though, even in the realm of matter theory. He presents arguments from faith for constraints on the nature of matter and its ultimate constituents, and these are not derived from empirical data. Rather, they follow from foundational claims in theology and theological cosmology, as for example concerning the generation and corruption of matter, including and especially atoms. All the same, an appeal to experience is the final determinant of the particulars of whatever matter theory is workable given the constraints of Holy Writ. In this way, the method of attaining—and retaining—such particular claims (as concerns the qualities, behavior, or macro-level phenomena produced by, atoms) sustains their probable nature, regardless of the more certain nature of the constraints themselves.

The relation of Gassendi's atomism and probabilism may even be said to be mutually *supportive*. Adopting atomism as the matter theory of choice allows an enhancement of his probabilist method, by licensing appeals to ampliative inference in mechanical explanation.

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<sup>5</sup> Such inferences from the surface-level phenomena *are* the starting point for many component claims in Gassendi's atomist programme, as concern the contribution of atoms to macro-level phenomena, and in those more limited case he may better approximate at least this primary aspect of the *regressus*.

<sup>6</sup> There are other ways, accordingly, in which Gassendi's atomist reasoning fails to observe the *regressus* model—including the search for a middle term and the reversal of the discovery process in the explanatory mode—but satisfaction of those elements is in any case contingent on satisfaction of the primary step of reasoning from effects to causes.

Thus, consider the implicit notion, operative in several places throughout his physics, that nomic or law-like characterizations of matter should range over the visible and subvisible alike (notably, such characterizations govern basic phenomenal features like the universality of contact action and consistent interaction of extended objects with varying geometries).<sup>7</sup> Optimally, the preferred matter theory should account for material phenomena in a correspondingly general way. As we saw in chapter ten, one attractive aspect of the atomist hypothesis in this regard is that it yields mechanical explanations that are scalar invariant, for all supra-atomic bodies. The exceptions in Gassendi's account are the peculiar qualities of atoms themselves, especially relative to atomic motion. Those exceptions aside, though, the same general causal accounts on the atomist model explain why the smallest molecules and largest supra-atomic bodies may have such similar qualities as hardness, density, or attraction. Any remaining differences across such explanations should account for the distinctive measures of their (otherwise similar) respective qualities.

By almost entirely ruling out the role of scale in physical explanation, this principle of Gassendi's atomism allows for mechanical accounts of any material phenomena regardless of whether they are perceivable. Embracing atomism thus removes one obstacle to ampliative inference from claims about the visible to claims about the subvisible. In this way, Gassendi's choice of matter theories shapes his model of scientific reasoning, by expanding the possible ways of accounting for a wide range of sub-perceivable phenomena. This expansion provides further reason for him to place his atomist hypothesis at the center of his physical, chemical, and natural historical accounts of the world—for in so doing he bolsters the explanatory breadth and power of mechanist approaches to those accounts.

Gassendi also seeks to widen the traditional scope of justification for beliefs about the subperceivable, and to this end he advocates drawing on the evidence of signs.<sup>8</sup> As noted above, he thereby broadens the range of admissible evidence that may be considered as collected from the senses—and so loosens the most stringent empiricist

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<sup>7</sup> We see such a notion at work in Gassendi's suggestions that the motion of celestial bodies differs by degree but not kind from that of terrestrial bodies, or that elements of similar molecules fit together with great regularity.

<sup>8</sup> Q.v. chapters two and twelve.

constraints on judgment of hypotheses without lessening his global commitment to empiricism. In the specific instance of the elements of matter, Gassendi proposes that we may identify signs of atoms or their behavior, just in case we detect phenomena explained only by the hypothesis that they are caused by properties of atoms, as for example their motions. At a minimum, this is a convenient view: any empirical evidence for the atomist hypothesis must be from signs because there is no direct epistemic access to these subvisible entities. In this vein, Gassendi draws on two sorts of sign-based evidence, appealing to directly and indirectly perceivable phenomena we identify as signs.

In the first case, evidence for atomism is adduced from signs found in directly observable phenomena—what may be perceived ‘on the surface’—and what counts as signs is determinable *a priori*. Specifically, surface-level phenomena can be interpreted as signs of atomic behavior if there is only one plausible explanation (namely, an atomistic one) of such phenomena. In this regard he cites the Epicurean prescription that we ‘*distinguish attentively between the things which have only one way to agree with sensible appearances and those which may agree in many ways with what occurs around us*’:

Since natural philosophy consists of judging things that are hidden from us in accordance with those which are perceivable by their appearances, Epicurus wanted to distinguish between things that manifest themselves as if they can only happen in one way, and those for which it is possible to happen in many ways. Thus, while we could say that those which can only occur in one way take place in a particular fashion to which sensible appearances correspond, we could not say the same of those which can occur in many ways, neither that they would take place in the same particular fashion, nor that their sensible appearances would correspond accordingly. In the first group he includes the existence of the void and indivisibility of principles. To the second group he says belongs what he calls the SUBLIME [*sublimia*]—as for example the lunar phases, eclipses, comets, thunder, etc., all phenomena for which he endeavored to give the ways and numerous causes.<sup>9</sup>

Neither atoms (the ‘principles’) nor void themselves have any direct appearances, so this first group must include phenomena or entities we identify indirectly by appealing to surface-level phenomena we

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<sup>9</sup> O VI 156a–b; letter to Valois (October 3, 1642). For the original Epicurean rule, q.v. the *Letter to Pythocles*.



take as occurring in one way only—in this case, by the confluence of underlying atomic states, their interactions, and the presence of the void. There is not much room for maneuvering once such phenomena are assigned to the first group. To claim that “those which can only occur in one way take place in a certain fashion to which sensible appearances correspond” is to designate a causal account in tandem with or in advance of identifying (much less interpreting) the sign. This does not have the makings of a successful strategy. The very reason for identifying a phenomenon as belonging to the first group is that we cannot conceive of it occurring unless we assume that it occurs in one specific way—namely, according to the atomist account. Theoretical neutrality is thrown out from the beginning, on the grounds that we identify the manifest with a single possible underlying cause. This move in turn is predicated on the notion that we know what that cause is, which suggests that we gain nothing from the sign-based inference. One may conceive of an improved strategy here, which would license judgments of signs as indicating subperceivable phenomena not designated in advance (*whatever* that would turn out to be), just in case the appearances of surface-level phenomena could not occur otherwise.

This is not Gassendi’s tack, however, because he starts with the premise that, if available, an atomist account merits special consideration given its comparably great explanatory power. Thus he closely follows the Epicurean model in his proposed instances of surface-level signs of atomic behavior, as for example in the appearances of air at the top of barometric instruments (see chapter 5) and of attraction phenomena, explained as contact action (see chapter 11). In the Pascalian barometry experiments, he argues, there is only one plausible way to account for what appears to be empty space through which light and other fine particles may pass: there must be an interstitial void at the top of the instrument. Without stipulating at least a partial void, there is no other way to explain the fact that an empty space appears without any open passage to the surrounding atmosphere. In addition, without stipulating particles which must be imperceptibly small, there is no other way to explain the fact that light corpuscles, for example, may pass through the glass body of the instrument and travel through or else remain interspersed with void. By stipulating even a partial, interstitial void, this account further suggests the atomist characterization of the tiny particles as discrete units of matter. A further step—not offered by Gassendi—would

have been to argue that were the ultimate particles discrete then it would be possible, *contra* the plenists, for them to be indivisible.<sup>10</sup> Even without this last step, though, he proposes that we can take the appearance of the seemingly empty space as a sign of matter's atomic structure: the only plausible account of the perceivable phenomena suggests that the underlying subperceivable phenomena consist of atoms traveling through a void. The weakest point in this chain of reasoning, unfortunately, comes in the preliminary suggestion that the surface-level phenomena could occur under no different circumstances.

For similar reasons, the attraction phenomena case is weaker still. Gassendi proposes that appearances of bodies being pulled towards each other or falling regularly to the ground should be taken as signs of underlying atomic bodies seizing and pulling one another, by means of hooks or like protrusions.<sup>11</sup> Regarding gravity, he rules out the possibility that bodies have an innate tendency to fall to the Earth. And regarding gravity and magnetism alike, he dismisses action-at-a-distance on the grounds that all physical events occur as a result of atomic states and interactions in the void (cf. chapter 11). By contrast, no action-at-a-distance account bears an atomistic interpretation. While his reasoning regarding 'tendencies' in the gravity case is plausible given Gassendi's arguments against Aristotelian 'natural' motion,<sup>12</sup> his more general line of reasoning for ruling out alternative accounts is purely stipulative and presumes that atomism—or something very close to it—is correct to begin with. It is unclear why there can be no other interpretation of such attraction phe-

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<sup>10</sup> On this reasoning, denying the void entails the continuity of matter, which precludes the possibility of discrete particles that, being indivisible, are truly ultimate. Thus if there were a void, matter could not be continuous and there would be some limit to its divisibility, say, at the atomic level. The actual plenist arguments are a little more complex. Descartes, for example, denies the void on the grounds that whatever there is, is extended (extension being a property of all matter). That there are no limits to the divisibility of matter is indeed consistent with this denial but does not follow as a straightforward consequence. Stipulating that there actually is a void should have no bearing, then, on the indivisibility of matter—and in any case would thus deny the antecedent. On the other hand, demonstrating the existence of a void, as we saw in chapter five, has a greater bearing on the issue.

<sup>11</sup> Q.v. chapter eleven. Gassendi identifies Democritus as the source for the theory of magnetic 'effluxions' among atoms; q.v. *O* II 123b.

<sup>12</sup> Q.v. *O* I 343 ff., *O* III (*MI*) 487b–488b.

nomena possible, and therefore, why appearances of the same should be taken as signs of atomic behavior.

The other sort of empirical evidence Gassendi thinks we have for atoms, which might be construed (at least at first glance) as sign-based, is found in phenomena that are seen through a microscope and so only indirectly perceivable. Thus, in a letter to Peiresc (July 6, 1635), Gassendi proclaims that his crystallization experiments confirm “one of my old dreams [*resveries*] concerning the principles of the philosophy of Epicurus” by establishing that there are structures which maintain their basic shape though they are broken down into smaller and yet smaller sized forms. He bases this claim on results he obtains through a ‘resolution’ process of dissolving crystals.<sup>13</sup>

... I recognize in particular that these large solid forms—whether cubes, octahedrons, or others—are composed of other lesser ones of the same shape, and that those [forms] of the lesser ones—until they are resolved into very minute ones—are almost insensible and remain shaped in the same way, from which I conclude that they can be resolved until their [constituent] atoms, which by some sort of necessity must be of the same shape. The composition demonstrates this, by the manner in which I observe that they grow larger from the moment that they become like [the size of] mites.<sup>14</sup>

When we dissolve larger crystalline structures of salt or alum in water, the smaller crystals maintain the same shapes, down to the point that the forms can no longer be seen with the naked eye. In principle, we should be able to continuously dissolve the crystals until reaching the atoms they comprise. Further, given that each successive dissolution perceived through a microscope produces crystals of an identical shape, it is conceivable that we should find that shape on the atomic level, too.

Of course, Gassendi does not pretend to see atoms or even atomic aggregates through the microscope. He proposes instead to take the shapes of small crystals he *does* see—when peering through the lens—

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<sup>13</sup> It is tempting to see in such physical or chemical processes an analogue to the resolution element of the *regressus* by which we would determine that microstructures bear the underlying causal features of the macro-structures. Though this experiment was concluded some ten years before Gassendi’s discussion of the *regressus* in the *Logic*, earlier manuscripts (viz. Carpentras ms. 1832 (1636); q.v. Jones (1981)) discuss the same method. In any case, there is no specific textual evidence that Gassendi conceived of the two analytic modes as conceptually linked.

<sup>14</sup> *TdL* 538–539.

as signs of the shapes atoms or their aggregates feature. The suggestion is that the identity between forms of the largest and smallest crystals perceived indicates that the large crystals' forms are legitimate signs of the small ones' forms. Since the smallest crystals detected are formed from other, yet smaller constituents, *these* should also have forms identical to those crystals they compose, on the grounds that all those on a larger scale bear the same identity vis-à-vis the crystals *they* compose. Accordingly, by this 'transductive' inference, we should be able to take the forms of the smallest crystals we detect as indirect evidence—signs—of the forms of those still smaller, subvisible crystals. This sort of inference should be applicable, Gassendi proposes, all the way down to the level of the molecules constituting those crystals, and perhaps even to the level of Epicurean atoms.

Looking beyond form *per se*, Gassendi's strategy could not be used to adduce evidence for the structure of atoms because—even by the lights of classical or early modern views—no atoms have a crystalline structure for which any higher-order crystals could serve as signs.<sup>15</sup> It is more plausible that this strategy yield evidence for his view that crystalline structures are persistent across the scale of supra-atomic bodies, including bodies below the level of unmagnified perception; strictly speaking, this is just what he claims regarding his microscopy observations. However, here too he runs into difficulties. For one, Gassendi infers that the lowest-order crystals we can detect (through a microscope) may serve as signs from the successful role that higher-order crystals play as signs. Yet it is not clear what sorts of signs these might be. Nothing about either of the putative signs he proposes is such that, without the phenomena for which we take them as signs, these more familiar phenomena could not occur. Hence they fail to satisfy his rule for identifying indicative signs. Moreover, they cannot be commemorative signs, for there is no past instance of the unperceived forms being detected at all, much less as having been a contributing factor to the emergence of perceived forms. Instead, in this instance, we are supposed to recognize the higher-order crystals as signs because microscopy demonstrates the prop-

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<sup>15</sup> To be sure, Gassendi's references to crystalline forms here are in terms of component solids such as cubes and octahedrons, which might well represent atomic shapes. But *their* structures would not be crystalline, as their aggregates might be.

erly analogous or even identical crystalline structure in component crystals, and we are to infer by analogy that the same holds true of any lower-order component crystals. Although Gassendi does not neglect or deny the value of reasoning by analogy (q.v. the *Logic*, Book 3, Canon XIII),<sup>16</sup> his guidelines for sign-based reasoning are not satisfied in this instance. The best that might be said here is that the connection between the relata of the analogy should turn out to be a satisfactory sign relation, depending on the contribution of the lower crystal forms to the higher ones. Until such a contribution to the higher forms is established, however, this is hardly the stuff of dreams confirmed.

Even without the canonical foundations of Gassendi's theory of signs, though, this experimental account constitutes a significant effort to justify the reasoning underlying early modern microscopy, in its powerful suggestions that stable structures which *are* perceivable may be taken as signs of stable structures which *are not*, and that we might iterate this strategy until we had an account of matter's ultimate particles. For all the promise of this strategy, Gassendi later on may have lowered his confidence in this analogy, or else seen that the conditions were not met for taking the higher-order forms as signs, strictly speaking. The crystallization account is reproduced in the *Syntagma*, two decades thereafter, without such earlier hopes for providing evidence on behalf of atomism. In this later context, he appeals to the crystallization experiments as empirical demonstration of the hypothesis that crystals have underlying molecular structures, while suggesting that the same experiments do not necessarily yield evidence for the constituent atoms of such structures.<sup>17</sup>

The crystal resolution account is exemplary of Gassendi's appeals to the atomic structure of the world in characterizing a wide span of natural phenomena, including the geological, chemical, and meteorological. Such broad appeals indicate the robust character of the atomist programme; they do not, for all that, indicate that atomism

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<sup>16</sup> O I 114a–b; Jones (1981), 139–141.

<sup>17</sup> O I 271a, 472a. For Gassendi, the structure of molecules is a function in part of the solidity of atoms, as the latter lends the former some element of stability, aside from any cohesive forces (which he does not discuss) and interlocking connections (which, as we have seen, he does discuss). If he took this relationship between the two to suggest that an empirical argument for molecular structures yields such an argument for atomism, though, he does not express as much.

is correct. All the same, his arguments for individual elements of that programme contribute to a larger strategy of establishing that atomism bests all other competing matter theories in accounting for the available evidence—and so comes closest to approximating the truth. Thus, quite apart from his various appeals the *regressus*, reasoning by analogy, or sign-based inference, Gassendi's grand strategy or 'long argument' in defense of atomism takes the form of inference to the best explanation—akin (though not identical) to what Peirce would later call 'abductive' reasoning.<sup>18</sup> Some commentators (including Brundell, Jones, and Joy) see Gassendi's strategy of reviewing past and current perspectives on matter theory as primarily an historical exercise towards the end of providing a convincing pedigree for atomism—a particularly important goal in light of the Church's anti-atomist sentiments. However, while Gassendi is tremendously concerned from a theological perspective with Church views on the structure of the world, the strategy of his pronounced and lengthy philosophical defense of atomism is to describe the contrast class of competing theories, against which he gauges atomism's accounts of perceptual data as the most successful.<sup>19</sup> Those competing theories include classical hylomorphism, cartesian corpuscularianism, and matter theories upholding rationally or mystically-determined ultimate structures, including neo-Platonist appeals to ideal solids and the *anima mundi* views of Kepler, Fludd, and the Rosicrucians. According to Gassendi, the reason for such great explanatory success across a wide range of accounts of natural phenomena *P* is that atomism best accounts for what he sees as all relevant constituent phenomena of *P*, including the coming together and falling apart of *whatever* might

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<sup>18</sup> Peirce presents the pattern of abductive reasoning as follows: "The surprising fact, C, is observed; But if A were true, C would be a matter of course, Hence, there is reason to suspect that A is true." (*Collected Papers* 5.181). Peirce's account has a long historical provenance: this pattern neatly captures that of the Stoic inference (so frequently cited by Gassendi) to the existence of pores in the skin. As Burch notes, though, Peircean abduction need not be inference to the *best* explanation *per se*; it might simply consist in inference to an explanation that elucidates or renders predictable information that was previously unexpected; q.v. Robert W. Burch, "Charles Sanders Peirce" (2001), in Zalta (1995–), <http://plato.stanford.edu/entries/peirce>.

<sup>19</sup> This is not to say that there is a hard distinction between philosophy and theology for Gassendi; rather, these are often intertwined threads in his thinking. Yet a balanced view of his atomist strategy cannot focus on his theological motivations alone, particularly given his discussion of a range of philosophically-inflected matter theories.

count as fundamental bits of matter, and coming into being of such basic qualities of supra-atomic bodies as solidity, size, density, and hardness.<sup>20</sup>

Gassendi's use of inference to the best explanation (IBE) on behalf of atomism is typical to the form, employing this usual inference structure for choosing among hypotheses:

1. For competing hypotheses  $H$ :  $\{H_1, H_2, \dots, H_n\}$  and available evidence  $E$ :  $\{E_1, E_2, \dots, E_n\}$ , some  $H_i$  best explains  $E$ .
2. That a hypothesis best explains the evidence constitutes evidence of its truth.  
therefore
3. We are justified in believing  $H_i$ .<sup>21</sup>

A satisfactory account of IBE would buttress such justification by providing at least these elements of support: the viability of inferential structure of the argument (1–3) as an independent form of reasoning, the *truth* of those hypotheses elected as the 'best' so as to warrant our belief, and the particular justificatory features of 'best' hypotheses (as assigned to such IBE arguments). This last element entails satisfactory criteria according to which  $H_i$  best explains  $E$ , and as the contemporary literature on IBE suggests, these criteria might include the breadth of evidence explained, simplicity of explanation, capacity to unify disparate theories, avoidance of *ad hoc* assumptions, coherence with other beliefs held, or other such relations as the explanation of lower-level accounts by higher-level accounts.<sup>22</sup>

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<sup>20</sup> O I 270a–281a.

<sup>21</sup> This form of reasoning regarding theory *choice* may be seen as an expansion on the similar role Gassendi outlines for verisimilitude in deciding on the *viability* of hypotheses (cf. chapter six). In the present context of comparing theories for the purpose of choosing among them, verisimilitude is retained as a significant criterion, one central ingredient of what counts as the 'best' explanation.

<sup>22</sup> The strongest proponent of IBE in the contemporary literature is Peter Lipton, who refers to these explanatory 'virtues' collectively as 'loveliness'—rather than 'likeness'—of explanation; q.v. *Inference to the Best Explanation* (London; New York: Routledge, 1991). Lipton has argued that loveliness could be consonant with, or even indicative of, likelihood; q.v. "What Good is an Explanation?", in *Explanation: Theoretical Approaches and Applications*, ed. Giora Hon & Sam S. Rakover (Dordrecht; Boston: Kluwer Academic Publishers, 2001), 43–59; and "Is Explanation a Guide to Inference?", in Hon & Rakover (eds.) (2001), 93–120. Similarly, Cartwright recommends that inference to the most probable cause is a compelling form of IBE; q.v. Nancy Cartwright, *How the Laws of Physics Lie* (Oxford: Clarendon Press; New York: Oxford University Press, 1983). By contrast, van Fraassen suggests that such

For Gassendi's part, we have seen, the 'best' hypothesis is determined by its explanatory breadth, or having the greatest explanatory utility. There are several reasons, he suggests, why atomism better accounts for a wide range of natural phenomena than the competing theories. For one, as I suggested in chapter eleven, atomism allows him to explain away at least some types of occult forces, including notably those entailed by mystical *anima mundi* accounts and action-at-a-distance theories. For another, atomism is at least partly empirically founded and so empirically testable. Finally, as we saw above, atomism facilitates appeals to the mechanical philosophy in explaining a great panoply of natural phenomena. Facilitating such appeals widens the range of phenomena present to the senses that can be explained by the matter theory of choice. It has the further consequence, we will see below, of permitting a widened range of possible *evidence* on behalf of that theory.

First, however, let us consider one common complaint against IBE, in the manner that Gassendi deploys it here: the explanatory utility of a given causal hypothesis (such as atomist matter theory) ought to be irrelevant to its selection as most worthy or credible, if such

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strategies lead us to violate the probability calculus; q.v. Bas van Fraassen, *The Scientific Image* (Oxford: Clarendon Press; New York: Oxford University Press, 1980). And Achinstein argues that what makes an explanatory hypothesis H 'best' cannot make it anymore likely than  $p = .5$  (q.v. Peter Achinstein "Inference to the Best Explanation: Or, Who Won the Mill-Whewell Debate?", *Studies in the History and Philosophy of Science* 23 (1992) 349–364, esp. 361–364, and *Particles and Waves: Historical Essays in the Philosophy of Science* (New York: Oxford University Press, 1991), 123–133): given any H' incompatible with H that entails the same observed phenomena—and where  $p(H'|B) \geq p(H|B)$  on the same background information B—for whatever observed phenomena entailed or explained by derivation,  $p(H) \leq .5$  (p 363). In other words, any new H' can be introduced which explains the phenomena as well as the 'best' H, given identical background information, no matter what explanatory power is attributed to H. Achinstein is concerned in particular with Whewellian 'consilience' and coherence but suggests that the same should hold for the other explanatory 'virtues'. Significantly, though, if the background information B is not held constant, then this complaint against IBE falls apart. As we see below, this is what Gassendi recommends: a change in hypothesis brings on a change in background information, with the probabilities shifting accordingly.

Another difficulty with tying the explanatory virtues to 'likeliness' is that we get to *truth* through 'likely' no better than through 'best'—and we might well have an H that is true yet deemed unlikely (at least by prior probability) which we still want to say best explains the observed phenomena. This difficulty is particularly acute for those who—like Gassendi—hold that the most we can hope for is truth-likeness, the judgment of which will be even more challenging than usual given the unlikelihood of H.



a hypothesis turns out to be false. In other words, ‘best’ is not a guarantee of truth, and only true hypotheses are warranted.<sup>23</sup> One scenario under which ‘best’ may not even come close to the truth is if all the candidate hypotheses available are bad ones. Such a complaint presumes that there is no truth-indexed notion of a minimum viability for candidate hypotheses—and whether or not this presumption is reasonable,<sup>24</sup> Gassendi for his part offers no direct insight on this specific question. More broadly, though, this complaint highlights the question of how candidates are determined to be viable to begin with. On this issue, Gassendi weighs in, embracing the view (at least operatively) that a putative evidential equivalence of hypotheses cannot be assumed as a factor in determining minimum viability.

This much can be seen in Gassendi’s judgment among matter theories, where he takes the candidate hypotheses to initially bear unequal evidence. The notion is that identifying such candidates as viable possibilities—much less ‘best’—cannot require that the evidence for them is equal given that the relative evidence is one criterion of the best hypothesis. This is suggested by his earnest contemplation of various matter theories with starkly differing possibilities for bearing evidence. His view, in short, is that we need not start from a position

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<sup>23</sup> The classic proposal has it that IBE inferences take us from explanatory features of an hypothesis to its truth via rejection of all plausible alternatives, which is supposed to yield the verity of the hypothesis left standing; q.v. Gilbert Harman, “The Inference to the Best Explanation”, *Philosophical Review* 74 (1965), 88–95, esp. 89. As McMullin notes, though, this is rather inference to the *only* hypothesis (not the *best* one), and what one actually gains from rejecting the alternatives is the *best available* hypothesis; q.v. Ernan McMullin, “Explanatory Success and the Truth of Theory”, in *Scientific Inquiry in Philosophical Perspective*, ed. Nicholas Rescher (Lanham, MD: University Press of America, 1987), 51–73, esp. 65–66. McMullin proposes that the scientific realist is in the best position to salvage truth from satisfaction of the ‘best available’ criteria, on the grounds that this should also satisfy coherence conditions that carry over, for the realist, to warrant for the truth of theories (1987, 66–67). Yet it is not clear that the empiricist is disadvantaged here, as we can see from Gassendi’s notion that any view that satisfies the ‘best available’ criteria and our best empirical evidence is as close to the truth as any view on hand. While the warrant criteria for the truth of theories differ from that of the realist, the satisfaction of the corresponding conditions for truth or verisimilitude of theories takes us beyond election of hypotheses as ‘merely’ the ‘best available’.

<sup>24</sup> Lipton’s response to this scenario focuses on established viability of hypotheses, but relative only to the best candidate—and indexed to ‘goodness’, and not truth *per se*. IBE should only license such inferences to H when the best candidate is indeed good (2001, 104).

of equivalent evidence for alternative hypotheses in order to initially pick and then weigh the candidates. The process for identifying the best explanation starts instead with gauging capacities *en gros* for explanatory power—broadly defined so as to include variations in evidence predicted or produced.<sup>25</sup>

Indeed, Gassendi's notion of explanatory power is sufficiently broad that he takes as one indication of a given hypothesis as offering the *best* explanation its capacity to generate further evidence on behalf of the *selfsame* hypothesis.<sup>26</sup> Thus the atomist hypothesis bests its com-

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<sup>25</sup> One contrasting modern view is that candidate hypotheses under consideration must be evidentially equivalent: IBE arguments begin from the same batch of accepted or 'starting' facts, and are used to infer to one among several competing hypotheses based on their varying explanatory power. Were the evidence to differ, then predictive power would be determined by—in a sense, be the same as—explanatory power, and one could judge the best hypothesis by the former rather than the latter, contrary to the central IBE impulse. Moreover, that scheme should be untenable, since explanatory and predictive power cannot be identical given asymmetries between the two; q.v. Timothy Day & Harold Kincaid, "Putting Inference to the Best Explanation in Its Place", *Synthese* 98 (1994), 271–295. From Gassendi's perspective, though, explanatory power is partly a function of the number of things which need to be explained, hence there is no reason to think that we cannot judge between two or more hypotheses by their explanatory power just because the initial evidence for each is unequal. Indeed, their inequality in this regard gives us a means of gauging their relative merits. While Gassendi's view—shared by other early modern defenders of corpuscularianism, notably including Boyle—clearly depends on his notion of explanatory power, nothing in that notion forces predictive power as a criterion for choosing among hypotheses. This is because predictions may still be equivalent phenomenally though the underlying explanations (and explananda) differ greatly, as Gassendi notes relative to the grand astronomical theories of Tycho and Copernicus (q.v. for example *O IV (Institutio Astronomica)* 61b; *IA* 133).

<sup>26</sup> This proposal looks like Kitcher's notion that explanatory power is forward-looking, in that it entails the capacity of a candidate hypothesis to offer robust explanatory patterns; q.v. Philip Kitcher, "Explanatory Unification", *Philosophy of Science* 48 (1981), 503–31. A key difference is that, while Kitcher is concerned with creating future explanation (with an economy of reasoning) Gassendi's view suggests instead a concern with creating future justification for the very hypotheses under consideration (by broadening our notion of what is admissible as evidence).

Intriguingly, Gassendi's view also anticipates Hempel's more narrow proposal that there are 'self-evidencing' explanations, wherein the explanandum contributes critically to the rationale for taking the explanans to be correct; q.v. Carl Gustav Hempel, *Aspects of Scientific Explanation, and Other Essays in the Philosophy of Science* (New York: Free Press, 1965), 370–374. We understand certain facts about the phenomenon or structure to be explained as evidence for the given explanation under consideration. The reason to admit such explanations *qua* 'self-evidencing' is that, by taking said explanation to be correct (on the basis of such evidence) we obtain a satisfactory—perhaps optimal—account of the evidence. Although the model here is that H explains E and E justifies H, Hempel does not see this as an instance of

petitors relative to explanatory power in part because, by contrast, there is sufficiently less available evidence for competing hypotheses that they fail to explain “enough”—they suffer a deficit in explanatory power.<sup>27</sup> A strength of the atomist hypothesis in this regard is that its acceptance leads us, through an optics premised on a corpuscularian theory of light, to additional evidence on behalf of corpuscularian views generally, and perhaps atomism specifically.<sup>28</sup> In the case of other competitions among hypotheses, though, there may be *no* available appeal to the generation of further evidence—and indeed there may be no single hypotheses with the greatest amount of evidence altogether. It is possible, Gassendi recognizes, for hypotheses to feature more or less equivalent explanatory power, relative to evidence produced. This situation pertains in the instance of the grand astronomical hypotheses offered by Tycho and Copernicus. The equivalence of the evidence for those hypotheses—or, consequently, their explanatory power—does not prevent Gassendi from

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circularity: ostensibly explanation and justification are sufficiently different epistemic enterprises that their constituent elements of reasoning need not interlock in a vicious fashion. One instance of this would be where some hard-to-detect phenomenon A (which stands as hypothesis H) explains detectable phenomenon B (which stands as evidence E)—which is interpreted instrumentally as a product of A, although detection of B (that is, E) is taken as evidence for A (that is, H). In Lipton’s example (2001, 45), *v* (galaxy recession) explains redshift of characteristic spectrum, whilst redshift is taken as evidence for the specified *v*.

Another anticipation of Hempel’s view can be found in Whewell’s appeal to the relative explanatory virtues of consilience and coherence as means of selecting explanatory hypotheses (q.v. William Whewell, *The Philosophy of the Inductive Sciences*, London, 1840, volume 2, chapter 5, esp. § 11, 230–233). In particular, the Whewellian notion of consilience entails that a hypothesis H is formulated to explain one kind of phenomena yet allows the explanation of other, new kinds of phenomena—which further explanatory power counts on behalf of H as against the alternatives. ‘New’ kinds here may be profitably understood as being previously unobserved or undetected—and not initially thought to be accounted for by H. Here, too, IBE is defended (in this case, *contra* Millian inductive method) on the grounds that hypotheses may be judged by explanatory power broadly construed so as to include relative capacities to yield new and different sorts of evidence. As Achinstein notes (1992, 358), what exactly counts as ‘new’ evidence is nevertheless a critical point, little discussed by Whewell.

<sup>27</sup> It might be thought that Aristotelian prime matter theory features as great explanatory power as does atomism because they share the same broad explanandum: change. Yet the explanandum is not the same in each case. The term ‘change’ is sufficiently theory-laden that Gassendi (and other early modern corpuscularians, with the exception of Sennert) cannot accept that change occurs in matter as Aristotelians recognize it lest he accede to their prime matter theory.

<sup>28</sup> I discuss drawbacks of this line of reasoning in chapter fourteen.

employing an IBE strategy here.<sup>29</sup> Yet as the matter theory case illustrates, he does not take evidentiary equivalence to be a *necessary* condition for IBE strategies, either.

Another complaint registered against IBE strategies is the hard-line deflationist claim that they feature *no* necessary conditions (or any other conditions) because, in the end, no such strategies constitute independent forms of reasoning.<sup>30</sup> For Gassendi, this question arises prominently in his apparent appeal to IBE in the context of

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<sup>29</sup> Although Gassendi views the evidence for the Tychean and Copernican views as more or less equivalent, he suggests that the former offers the best explanation, at least insofar as one's conception of 'best' entails 'doctrinally consistent' and the doctrine entails that the Earth does not move (some commentators have taken Gassendi's stress on the contingent nature of this doctrinal interpretation to be a sign of Gassendi's continued support for Galileo and Copernicus; q.v. Brush (1972, 150 n 22), Jones (1988), and Bloch (1971)). However, beyond his signaling that Church teachings support the Tychean account (q.v. *O III (MI)* 519a–b, *B* 148; *O I* 148b–149a, *B* 149), he also details Tychean objections to the Copernican picture from physics (that the Earth should be too heavy a body to be moved by the ethereal heavenly bodies) and astronomy (the space between Saturn's orbit and the eighth sphere is great but supposed by Copernicus, counterintuitively, to be empty of heavenly bodies); q.v. *O IV (Institutio Astronomica)* 62a; *IA* 133.

What we do not find, except on scriptural or theological grounds, is an account of how 'doctrinally consistent' is explanatorily beneficial. This is all the more unsatisfactory because Gassendi acknowledges (all the while rejecting) the Copernican suggestion that Holy Writ does not intend to view the natural world as do the Physicians or Mathematicians, but through mundane appearances—in which context divine glory is all the clearer; q.v. *O IV (Institutio Astronomica)* 58b; *IA* 127.

<sup>30</sup> There are, globally, three contending positions on this issue. At one extreme, IBE may be seen to be truly foundational, as per Harman's notion that it is the bedrock of all ampliative inference (1965). At another extreme, IBE may be taken to be wholly derivative, as Day & Kincaid claim (1994). They argue that such strategies are useful under some circumstances, not possibly compelling under others, and that this variable utility is determined by such contextual factors as the audience for a given explanation and the background information they bring to bear on a choice of hypotheses. In the middle of these extremes lies the claim (in recent times propounded by Lipton (1991, 2001)) that IBE sits astride other free-standing forms of reasoning, prominently including hypothetico-deductivism (H-D) and classic enumerative induction, as a model of scientific inference to confirm or otherwise adjudicate among hypotheses.

In contrast to the view that the utility of IBE is contextually-defined, Gassendi holds that criteria for electing a given H as 'best' may be independent of context. Notably, atomism may be judged as 'best' among matter theories not only because it is coherent and tells a causal story with great explanatory power but because it stands as an alternative to theories which are unacceptable on other (for example, theological) grounds, and because it enables us to expand and develop our means of reasoning empirically. Neither of these are necessarily context-bound factors or explanatorily trivial.

indicative sign-based inference, which he relies upon to judge the viability of hypotheses (it is another question, which I do not address here, as to whether it also arises in the case of his appealing to IBE to choose among competing theories). In these instances, what initially looks an application of IBE might rather be construed as use of an inductive strategy, if our appeal to the signed-phenomena as the best explanation is the product of expectations based on recurrent events. Before entertaining this argument in detail, it should be observed that some forms of sign-based inference clearly cannot even be mistaken for species of IBE reasoning to begin with. As we saw in chapter 2, different sorts of signs are governed by distinctive rules for warranting claims we infer about the nonevident. In the case of commemorative signs, we are warranted just in case we have good reason to believe the phenomena taken as signs were previously and regularly associated with those phenomena for which we take them to be signs (smoke as a sign of fire is Gassendi's standard and classically-derived case). Commemorative sign-based inference, then, is a species of induction. Further, in another mode of sign-based inference, recommended for assessing evidence provided by microscopy, we rely on induction and reasoning by analogy to designate perceivable phenomena as signs of what we cannot perceive. In this reasoning, past cases justify the belief that the former are appropriate analogues of the latter.

Yet not all sign-based inference relies on induction so apparently, if at all. As outlined in the *Logic*, Gassendi's standard views of indicative sign-based inference is that such signs as we identify in surface-level phenomena are warranted just in case it is not possible to otherwise account for the presence of the phenomena we take as those signs. This reasoning moves from there being no better alternative accounts available for what we detect on the surface, to the claim that the only explanation left standing has the greatest viability. In short, it seems that an IBE strategy is at work.

Whether this is to genuinely count as inference to the best explanation depends on how the underlying reasoning here is construed. Thus, the suggestion that there are no better accounts available because it would be impossible (on pain of contradiction) to explain the surface-level phenomena given any other hypothesis may be seen not as IBE *per se* but as a straightforward deduction of the form

1. if Q were not the case then P could not be the case
2. P is the case  
therefore
3. Q is the case<sup>31</sup>

Here a simple application of *modus tollens* yields what may be the *only* account but is in no ways identified as the best account. This is not, however, a satisfactory parsing of Gassendi's model, as such applications of *modus tollens* fail to capture or communicate the import of the sign. This import is to tell us *why* (1) is true, that is, why P being the case depends on Q being the case or, at a minimum, why we would take it to be true that P being the case depends on Q being the case. Capturing that import thus amounts to further explicating what makes P a warranted sign of Q, which suggests in turn that Gassendi's irreducible concern is with IBE, or what makes that particular sign interpretation superior to its explanatory competitors.<sup>32</sup> Such a concern is seen over and over again in his frequent contrasting of the robust explanatory power of atomist accounts as against all competing accounts of natural phenomena.

On the other end of the spectrum, it might be thought that—as has been suggested of many putative instances of IBE—the underlying reasoning in justifying inferences from indicative signs is actually classical induction, after all. As Richard Fumerton has noted, an IBE argument of the form

1. P is the case
2. if Q were the case then we should expect P  
therefore
3. it is highly probable that Q

turns out to be an inductive argument of the form

1. P is the case
2. Q<sub>s</sub> generally bring about Ps  
therefore
3. it is highly probable that Q

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<sup>31</sup> For example, if it were not the case that skin had pores, then it could not be the case that sweat appears; but it is the case that sweat appears; hence it is the case that skin has pores.

<sup>32</sup> A remaining puzzle here, visited in chapter four is Gassendi's proposal that we make avoiding logical contradiction the mark of successful attribution of indicative signs or inferences to warranted claims from the same; there is no logical contradiction in supposing that even Gassendi's paradigmatic cases—such as sweat appearing without nonevident pores—are wrong.

if our basis for expecting P is the claim that, with sufficient regularity, Q leads to P.<sup>33</sup> If indeed this were the appropriate way to understand indicative sign-based inference, then such inference would not be particularly compelling just in case there were no grounds for such expectations. Gassendi, for his part, can only be taken to provide those grounds in his micro-level explanatory accounts, if we assume to begin with that his repeated appeals to the atomist hypotheses account for macro-level phenomena. This would have the makings of an empty strategy, if he failed to tell us why we should make such an assumption. In fact, though, Gassendi does tell us why we should make that assumption, and a consequence of his reason is revealing that this inductive reconstruction of his argumentation imports an appeal to IBE. For what is required in the inductive reconstruction are grounds for expecting that the micro-level phenomena regularly bring about the macro-level phenomena, and Gassendi's suggested reasons as to why we are entitled to those causal claims are actually one or another variation on the view that such claims represent the best explanations of the phenomena in question.<sup>34</sup>

In any case, the inductive scheme described above more accurately characterizes his proposal that we might expect to find some given evident phenomena because of the presence of some other, nonevident phenomena on the grounds of our belief that the latter generally bring about the former: that is precisely what commemorative signs are. Indicative signs, by contrast, are supposed to yield claims about phenomena that are nonevident in principle—there can be no 'observation' that what is not evident regularly brings about what is evident (and where there are subsequent empirical data it may be argued that the inference is converted to the commemorative). Rather, inferences based on these signs of the non-evident are

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<sup>33</sup> Richard Fumerton, "Inference to the Best Explanation", in Dancy & Sosa (1992), 208. Similarly, Achinstein proposes that IBE relies on enumerative induction by positing as 'best' those explanatory hypotheses that further instance prior, more general hypotheses of the same or similar form (1992, 361): H may be designated as 'best' just in case other, previous such  $H_1, \dots, H_n$  were meritorious. This last proposal falters, though, for such reasoning may rely on enumerative induction without entailing that the larger, encompassing arguments are not of a distinctive IBE form.

<sup>34</sup> This may seem circular, yet Gassendi may be able to appeal here to reasons that are not, strictly speaking, appeals to the regularity of the evidence; cf. chapter fourteen.

genuine instances of IBE, for the same reason that Gassendi's grand strategy for defending atomism against competing views constitutes such an appeal to the best explanation: Those claims we so infer are the best, he believes, because of their attendant explanatory power, not because of any truth-preserving character of the inference structure (per deduction), nor any ampliative assertions suggested by the evidence amassed (per classical induction). Such an appeal to explanatory power suggests that he conceives of his account of indicative sign-based inference as dependent on an IBE strategy conceived of as an independent form of reasoning.<sup>35</sup>

The broadest significance of Gassendi's appeal to an IBE strategy, either in his recommendation of particular appeals to indicative signs or in the context of his 'long argument' for atomism, is not so much any particular strength or weakness that marks his use of the strategy but that he employs IBE altogether to judge among causal hypotheses. In this he follows a general early modern trend of writers on method who focus on reasoning from effect to cause, whose numbers include Galileo, Bacon, Descartes, and Hobbes. Yet most of those writers—as with Gassendi in his 'official' method of the *Logic*—owe much to a *regressus*-style model. Gassendi by contrast moves away from a deductive approach and closer to an abductive approach, though the emphasis begins with hypotheses in either case. Another similarity is that, like Descartes and Hobbes in particular, Gassendi tries to articulate a resolution to the specific problem that multiple possible causes may appear to account for a given effect. For Descartes and Hobbes, if such underdetermination is resolvable at all, the solution is to be found in demonstrative reasoning.<sup>36</sup>

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<sup>35</sup> Taking IBE to represent an autonomous form of inference in Gassendi's thought leaves us with a picture of his appealing to a varied palette of forms of scientific reasoning, along with inductivist forms such as commemorative sign-based inference represents, and deductivist forms such as the *regressus* model represents. By this token, Detel is incorrect to consider deductivism—and specifically, hypothetico-deductivism—as Gassendi's dominant or preferred mode of scientific reasoning (2001, 7, 11). It may be countered that Detel is interested in Gassendi's reasoning about phenomena rather than his reasoning about the theories explaining the phenomena, but Detel himself draws the conclusion that Gassendi's reliance on deductivism renders his empiricism suspect. It bears mentioning, though, that even Gassendi's notion of deductivist inference is shaped by his unorthodox, 'probabilist' conception of how to count the evidential support of the premises for the conclusion.

<sup>36</sup> For Descartes, q.v. the clock analogy (*PP* Part IV §204 *AT VIII* 327); for Hobbes, q.v. *Decameron Physiologicum* (Molesworth edition) VII, 88 and *Problemata*



Descartes is especially optimistic on this score, proposing that we can deduce the correct hypotheses from infallible basic premises. By contrast, Gassendi has it that the solution lies in non-deductive discovery of the best—hence most likely—causal account.<sup>37</sup> So while numerous seventeenth century perspectives on method address the difficulty of divining causes from their effects, it is rather unusual to propose that the key to grasping such causes consists in identifying them as the best possible explanans of those effects, as gauged by varying facets of explanatory power. This strategy is all the more unusual in that Gassendi proposes that sensory evidence guides identification of the best explanans, thus characterizing IBE strategies as empirically robust means of reasoning to causal claims.<sup>38</sup>

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*Physica* IV, 209. Jesseph suggests that Hobbes disallows a science where causes may be inferred from sensible appearances because we cannot perceive the causes; q.v. Douglas Jesseph, *Squaring the Circle: The War between Hobbes and Wallis* (Chicago: University of Chicago Press, 1999). Horstmann (2001), by contrast, proposes that the problem for Hobbes is instead that we cannot produce, or reproduce, the effect from the cause; q.v. Frank D. Horstmann, “Hobbes on Hypotheses in Natural Philosophy”, *The Monist* 84 (2001) 4, 487–501. This would be a Hobbesian corollary to the Baconian notion that scientific inquiry is fundamentally experimental, or “maker’s knowledge”, yielding those facts about the world that we can engender through our own artifice (q.v. 489–491, and Pérez-Ramos, 1988). Given Horstmann’s reading, it emerges that physics may yield demonstrations of causes, after all, though they are only possible as they reflect reasoning from effects to causes rather than the other way around.

<sup>37</sup> One might argue that underdetermination remains, strictly speaking, in that no evidence verifies that the ‘best’ hypothesis is the ‘true’ one—though it is not clear what force this has against Gassendi’s contention that the best knowledge we can hope for is no greater than probable, anyway.

<sup>38</sup> Gassendi is clearly not altogether unique in promoting something like IBE; various authors have historically appealed to IBE for specifically non-empiricist ends, from Plato’s defense of forms to Descartes’s defense of vortices.



## CHAPTER FOURTEEN

### IS THERE A CIRCLE IN GASSENDI'S REASONING?

The most tantalizing promise of Gassendi's method and theory of knowledge is the empirical justification of his atomist views. Yet had he managed this feat—and there are places where he is convinced that he has done so—it would appear to come at a high price. Since Gassendi also defends his empiricist theory of warrant by appealing to his matter theory and its concomitant physical and psychological optics, there is minimally an appearance of circularity. There are two ways to address this charge: look for other defenses of his atomist or empiricist claims which do not engender the proposed circularity, or else view the circularity as admissible under the circumstances. The former approach, I suggest, cannot succeed given the extent of his atomism's debts to empiricism and vice-versa. This leaves Gassendi with a circle for which to account.

This circularity would pose a significant difficulty for Gassendi's constellation of views on the practice and nature of science, casting a shadow over his signal defenses of empiricism and atomism—among his primary contributions to early modern thought. As we have seen, the core development of his modern empiricism is a 'constructive' or 'mitigated' skepticist theory of warrant, according to which we justify beliefs about the world on the basis of sensory information and the justification specifically consists in the reliable representation of worldly phenomena by sensory data. This reliability, in turn, is ensured by the constitution of those data—impressions on sensory apparati by corpuscular emissions emanating from or reflected by the objects of sensation. The corpuscular constitution of the emissions and impressions means that even sensory distortions are explainable by recourse to the nature and behavior of bodies, rendering our grasp of the phenomenal characteristics of objects of sensation as either natively accurate or else easily accounted for by the appropriate physical account (per Gassendi's account in *De Apparente Magnitudine*). This proposal, however problematic in the details, offers one of the more compelling arguments of the early modern era for justifying empirical claims: we can know about the world on the

basis of sensory-based claims we judge as well-supported (if not guaranteed) by certain basic physical facts about the world and our interaction with it. Empirical knowledge is justified by appealing to the physiology of the senses and the fundamental material structure of the world. This is a rather modern approach to empirical knowledge that, to a degree, anticipates Hume and even contemporary naturalizing epistemologists. Yet, as I suggest below, Gassendi cannot quite lay claim to the modernity of more complete empiricists like Hume, given that his proposed empirical justification ultimately rests on *a priori* claims about the micro-structures underlying perception.

We have also seen the equally remarkable efforts of Gassendi to develop a matter theory and broad natural philosophy along empiricist lines by marshaling what he takes to be sensory-based evidence in support of an atomist view. The notable conceptual advance over contemporary fellow atomists is his drawing on a theory of epistemic warrant for signs of the subperceivable. The crucial role of Gassendi's theory of signs is underscored by the fact that his arguments for atomism have an empirical character only if he is correct about what constitutes warranted reasoning regarding empirical matters, and especially as concerns the subperceivable. One early and central motivation for introducing a matter theory with a supporting theory of empirical warrant is to improve on the Scholastic physics of his day, according to which the theoretical merits of an essentialist account of prime matter are that it is conceptually coherent, occasionally consistent with empirical results, and always consonant with (indeed, greatly shaped by) contemporary theology. Gassendi also espouses atomism on similar grounds, embracing the view partly as an element of a general rehabilitation of Epicurean thought, for which he tailors a fit with theological constraints. Yet Gassendi is as well firmly committed to an empirical defense of atomism, in contrast not only with views among the Scholastics but also with other, purely *a priori* defenses of corpuscularianism offered by, for example, Galileo and Descartes. As outlined in chapter seven, several peripatetic, hermetic, mystical, and corpuscularian traditions incorporated alchemical or iatrochemical investigations; defense of a matter theory by empirical means was hardly unique to or a novel aspect of Gassendi's thought.<sup>1</sup>

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<sup>1</sup> Cf. also Clericuzio (2000), chapters one-three.

What was novel in Gassendi's work was the marriage of empirical defenses to a theory of epistemic warrant that licenses those defenses. We next see this sort of appeal to the nature of the evidence for corpuscularianism in Boyle's *Excellency of the Mechanical Hypothesis*. As several commentators (Bloch and Osler among them) have noted, Boyle credits Gassendi (along with Descartes) with a modern formulation of a corpuscularian hypothesis, and in adopting this hypothesis Boyle clearly followed Gassendi either directly or else through the medium of Walter Charleton.<sup>2</sup> In this light, Gassendi's principal legacies in the Scientific Revolution are a theory of justification for empirical claims, and a matter theory that allows for broad and diverse application (across physical, chemical, biological, and yet other domains) and admits of empirical defense. His signal triumph is to have identified and wrestled with many of the difficulties any empiricist would face in promoting those two theories, and it is hardly disappointing that, as indicated in this study, Gassendi fails to adequately develop either theory. It may be more discouraging, however, to acknowledge that even were they adequate, there would remain the problem that for each theory his development of one appears to rely on prior development of the other.

Consider how Gassendi relates his arguments for atomism and his theory of warrant. The core claim of Gassendi's constructive skepticist programme—that we have reliable, probabilistic knowledge of the physical world—rests on the truth or, at least, verisimilitude of atomism. Yet he also counts signs of subvisible phenomena as compelling evidence for atomism on the grounds that such signs permit a limited, less-than-certain epistemic access to the nonevident. In particular, such access may be provided by inferences we license from signs to viable claims about what lies beyond our direct perceptual grasp. In sum, to accept the constructive skepticist theory of

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<sup>2</sup> Charleton offered a modified translation of portions of Gassendi's *Animadversiones* in his *Physiologia Epicuro-Gassendo-Charltoniana, or, A fabrick of science natural, upon the hypothesis of atoms founded by Epicurus; repaired by Petrus Gassendus; augmented by Walter Charleton* (London: Printed by Tho. Newcomb for Thomas Heath, 1654; Reprint edition, New York: Johnson Reprint, 1966). Q.v. also Bloch (1971, 272–273), and Osler, “Sources of Robert Boyle’s Philosophy of Nature: Gassendi’s Voluntarism, and Boyle’s Physico-Theological Project”, in *Philosophy, Science, and Religion in England, 1640–1700*, ed. Richard Kroll, Richard Ashcraft, and Perez Zagorin (Cambridge; New York: Cambridge University Press, 1992).

warrant requires that we endorse atomism, though accepting atomism—at least by Gassendi's empiricist standards—entails that we embrace that theory of warrant. A closer review of these arguments yields the precise points where circularity emerges:

First, atomism underpins the theory of warrant as follows. What sets early modern 'constructive' skepticism apart from classical strong skepticism are the claims of the former that we can know about the world though our knowledge cannot be certain, and that the justification for empirical beliefs consists in some feature of the sensory evidence adduced on their behalf. Gassendi in particular proposes that we can make warranted judgments about the physical world because our sensory inputs are reliable—either in the base case, as directly transmitted or else as per our cognitive processing of standard transformations—and because our judgments about those inputs are at least sometimes accurate. His grounds for suggesting that our sensory inputs are reliable in the base case are these: under normal conditions, our perceptual organs simply record physical interaction with the outside world without significant discrimination or manipulation, and so, without augmenting or diminishing information as occurs in mental operations on those inputs. This simple recording must itself be reliable, too, and this Gassendi assures us is guaranteed by the manner in which perceptual data are produced and in which perception occurs. In brief, groups of light atoms are transmitted from or reflected by sensed objects to sensory receptors, thus preserving intact the detectable characteristics of such objects at the point where those atomic aggregates are received and 'read' by our receptors.

As we saw in chapter 3, Gassendi provides some details of this story in his optical and visual perception theory. The transmission of images and light is borne by groups of corpuscles emitted by particular sorts of bodies like the sun or fire, or else reflected by the bodies whose images we perceive. Perceptions of images and light result from interactions of our retinas with those emissions or reflections. These elements of his optical and visual perception theory are proposed as a response to and update of the Scholastic view that images of objects that hit the retina are immaterial but film-like *species*, representations that transmit likenesses of those objects to the eye.<sup>3</sup>

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<sup>3</sup> *O III (AM)* 426b–427a.

Instead, Gassendi proposes, we perceive images of objects that do not themselves emit light; such objects *reflect* rays of light-corpuscles that consequently change configuration so as to bear images of the objects—which are then transmitted to our visual apparati through material impact upon the retina. In visual perception, these rays strike our eyes, with the different corpuscles included in a given ray representing corresponding parts of a thing we perceive. Perception of light *per se* simply entails that rays of light-corpuscles are emitted from the right sorts of bodies, or else reflected off others, with an intensity such that they bear no images at all.<sup>4</sup>

Gassendi draws on this account to address the Skeptic's worry, expressed in the Aenesidemean modes, that the senses may yield false information thus rendering them as unreliable sources of knowledge. The senses cannot yield false information, Gassendi counters, because they merely receive information impacting upon them. Following Epicurus (*DL* X 31–32), he proposes that the process of attaining sensory information is accurately executed if our receptors are in working order. Whatever unreliability we can attribute to sense-based knowledge, then, is the product not of sensory acts but of false inferences we make upon the faithful (if inadequate) information the senses provide. Thus, he suggests, we take rays emitted by perceived objects to represent the actual shapes and angles of those objects. If the object is close, then we perceive a sufficient number of distinctive rays to legitimately infer that we accurately detect the object's actual contours. In such cases we hold that the representation is accurate. If the object is far away, then the number of rays we perceive gives us an inadequate and deficient representation of the object, and inferences we make regarding its shape based on that representation are bound to be mistaken. Our failure to accurately sense far objects is, then, the result of mistaken inferences concerning information which is true but inadequate—as, for example, in a perceptual act featuring few distinguishable rays.<sup>5</sup> That we fail to attain empirical knowledge because of such poor inferences speaks less about the quality of our attendant reasoning than

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<sup>4</sup> Instances of visual distortions, anomalies, and the like quickly take us beyond the base case, and Gassendi strives to explain such in *Parhelia* and *De Apparente Magnitudine*, all by recourse to our native capacities to make consistent cognitive accommodations for such standard transformations of the objects of perception.

<sup>5</sup> Q.v., for example, *O* I 85a; *B* 344–345.

about the adequacies of our sensory information (though not about its fidelity *per se*). While this view clearly has its flaws—as noted in chapter 3—the point in this context is that Gassendi relies on his atomist-based theories of perception and light in defense of the claim that we have reliable knowledge of the physical world.

Looking in the other direction, we have seen that Gassendi relies on his account of empirical warrant to support an atomist hypothesis. This is an unsurprising consequence of his proposing a method which, consistent with his constructive skepticist programme, recommends that we tailor and maintain hypotheses about the nature of the world in accordance with evidence from the senses.<sup>6</sup> By contrast, he suggests, the Scholastics attempt to fit sensory evidence to accounts derived from reason alone and so are saddled with false evidence reports and unconfirmable theories.<sup>7</sup> For Gassendi, theory construction and choice are determined by empiricist considerations: we endorse a theory if it *best* explains a wide range of phenomena, which measure in turn is a function of the breadth and character of the evidence we gather. In the case of atomism, though, there is no direct evidence of the phenomena. Rather, the relevant evidence may consist of signs we understand as *indirectly* indicating imperceptible phenomena. To find evidence for atomism, then, requires gathering data that are apparent to the senses yet suggest the existence or features of atoms or atomic behavior.

In chapters five and thirteen we saw that Gassendi offers such evidence in accounts of Pascal's hydrostatics (barometry) experiment and of his own crystallization experiments. In these accounts Gassendi takes the visual data of surface-level phenomena (in the former case), or what he sees through the microscope (in the latter case)—as signs of molecular, and possibly atomic, phenomena. He assumes in each case that we cannot have the visual data without there being underlying atomic phenomena, which he takes as sufficient criterion to

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<sup>6</sup> Q.v. chapter six.

<sup>7</sup> Boyle offers a related, but distinctive criticism in his rejection of the Paracelsans and other 'chemists', whose doctrines he took to rely on obscure principles of indefinite character—that is, the *tria prima*—such that the many experiments and observations they conducted could not be fruitfully tied to clear and agreed-upon hypotheses; q.v. Chapter I, "On the Imperfection of the Chemists' Doctrine of Qualities", in *Selected Philosophical Papers of Robert Boyle*, ed. M. A. Stewart (Indianapolis; Cambridge: Hackett Publishing Company, 1991), 120–122.



qualify the former as indicative signs of the latter.<sup>8</sup> Yet the assumption that visual data indicate the presence of underlying micro-level phenomena is contingent on his notion that knowledge from signs is possible only if the data are reliable bases for empirical belief. That reliability is satisfied in turn by the optical and perceptual picture undergirding knowledge from the senses, direct or otherwise. In attempting to adduce empirical grounds for atomism, Gassendi appeals to characterizations of the micro-level physical world attainable through the medium of perceived signs—which depend on the assumption that his theory of warrant obtains.

We are left, then, with at least the appearance of a circle. Gassendi defends his theory of warrant by reference to his theory of perception, which is in turn built on his atomist matter theory, for which his empirical argument relies on the theory of warrant.<sup>9</sup> Thus, it seems, he can neither defend the atomist hypothesis by insisting on the cornerstone of his epistemic views, nor the other way around, on pain of circularity.<sup>10</sup> Some fundamental element of either his

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<sup>8</sup> He further assumes a physical continuity between macro-level and micro-level structures, such that bodies behave in the same general ways independent of size or scale, and together with the first assumption, this allows him to suggest that macro-level structures in the microscopy case provide viable analogues of the micro-level structures; q.v. chapter thirteen.

<sup>9</sup> Detel describes a more modest 'epistemic circularity' in Gassendi's thought: to judge normal conditions for perception and explain the causes of appearances (that we may invest belief in them) requires appealing to claims which are themselves subject to empirical confirmation, that is, by perceptual data (2002). Detel proposes that, while Gassendi does not address this problem of circularity directly, he lays out a viable strategy. First, he insists on the causal nature of the appearance of properties, *qua* individuals (Canon IV, *Institutio Logica*). Second, he proposes that the conditions must be varied to detect constancy of properties, and so judge that our appearances are reliable (Canon XI, *Institutio Logica*, O I 96b, VI 150a). Third, he develops a scientific account of perception and observation (q.v. O III (*AM*) 420–477) to help establish the reliability or 'validity' of those cognitive processes (Detel, 2002).

This proposed circularity differs from the one I have pointed to, the primary difference being that Detel highlights close-knit relations among Gassendi's epistemic claims, whereas I focus on broader ties, among the basic Gassendist epistemic and ontological claims. In Detel's proposed circle, Gassendi appeals to the nature of perceptual data to explain the warrant for empirical beliefs, though those data are in turn the objects of such belief. Detel sees the route to resolution in the Gassendist reliabilism and understanding of the underlying causal mechanisms of perception. This much is surely correct, as I suggest in chapter three. The problem, however, is that this route to resolution for Gassendi leads directly to his atomist ontology, and so in turn to the need for empirical confirmation of said matter theory. In short, granting the reliability of sensory data requires sufficient (*viz.* empirical) arguments for the matter theory, and thus for the perceptual theory.

<sup>10</sup> Historically speaking, the elements of this circularity emerge slowly over

physics or epistemology has to budge if this loop in his reasoning is to be avoided.

The traditional default strategy for defeating such circularity is to show that, appearances to the contrary, the putatively circular elements are not necessary for supporting one another. Thus, one might show that Gassendi does not really need his theory of warrant to generate evidence for atomism, or conversely, atomism to support that theory. Concerning the first option, some other epistemic principles not connected to the theory of signs might warrant empirical belief and so provide an acceptable alternative for licensing the kinds of inferences Gassendi takes to yield evidence for atomism. However, given his deep-seated conviction that all knowledge comes from the senses, a set of epistemic principles should be relevant in this context only if it provides some account of how perception contributes to belief. Since any such underlying account of perception is in his view an atomist one, choosing alternative epistemic principles does not help escape the charge of circularity.

Another, related move falling under this first option is to appeal to wholly other, non-epistemic principles to defend an atomist matter theory. As we have seen, Gassendi appeals to theology, the tradition of the ancient atomists, and a fair bit of *a priori* metaphysical reasoning in rallying for atomist claims. If epistemic principles were merely sufficient for defending his atomism, then the putative circularity would lose its significance. That is, if Gassendi intended to defend atomism *primarily* on non-empiricist grounds, his particular defense of empiricist knowledge on atomist grounds might yield a circle but would not present a problem for his global defense of atomism.<sup>11</sup> Yet this is not his intention. Gassendi strives to establish that there is no such thing as *a priori* knowledge (q.v. the *Exercitationes* and *Logic*), that all knowledge is ultimately rooted in experience (q.v.

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Gassendi's career. Thus, in the *Exercitationes* (1624) Gassendi has already eschewed skepticist orthodoxy for his 'middle way', suggesting that we address the problem of the criterion by a positive account of perceptual knowledge. Yet he does not explicitly propose that such an account relies on an atomist theory of light and matter until *De Apparente Magnitudine* (1642). The integrated package of elements yielding the proposed circle is not assembled in its entirety until the *Syntagma* (1658).

<sup>11</sup> Indeed, were such the case, the circularity claim might not even hold relative to the empiricist grounds for atomism, given that circularity requires necessary rather than merely sufficient grounds.

*Logic* and the *Disquisitio*), and that we should dispense with axiom-based physics and *a priori* astronomy models (q.v. the *Syntagma* and *Institutio Astronomica*), in favor of observational accounts and careful measurements (cf. chapters 1, 3, and 6). Along the same lines, it is a paramount concern for Gassendi to offer an empirical demonstration of atomism. We need not overly diminish the significance, frequency, or variety of his appeals to non-empirical, or even non-epistemic, principles to bolster atomist claims. His insistence on the primacy of knowledge from the senses indicates that his *core* defense is an appeal to the empirical evidence, which in turn requires an appeal to his theory of epistemic warrant. The diversity of his defenses of atomism does not remove the threat of circularity relative to the epistemically-rooted empiricist defense in particular.<sup>12</sup>

Concerning the second option, Gassendi might have avoided circularity as well by justifying his theory of warrant independent of background atomist considerations. In one such scenario, he might have adopted a materialist account of light, images, and their perception, solely in order to first dismiss the strong skeptic. Such a move would have thereby allowed the possibility of knowledge through the senses—in particular, through sign-based inference—and so permitted empirical support for the atomist matter theory.<sup>13</sup> A circle would remain, though perhaps not an onerous one, just in case Gassendi could produce independent reasons for maintaining his theory of warrant. Such a strategy would entail ‘borrowing’ support for one constituent claim of the circle in a manner *not* independent of support for the other constituent claim—but with the promise of

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<sup>12</sup> From a seventeenth century perspective, one might even construe his great attention to testimony of authorities for atomism as a reflection of empiricist interests as much as evidence from the senses. According to a prominent early modern view, testimony from persons and from the senses were all of a piece: admitting and devising means of measuring testimony from the senses were widely considered as simple and obvious extensions of admitting and devising legal and scientific standards for personal and written testimony. It is plausible, then, that Gassendi conceived of his arguments for atomism by reference to the witness of trustworthy scholars as resting on the same warrant as his appeals to the authoritative testimonies of sensory experiences. Barbara J. Shapiro (1983) reviews such early modern concerns with evidence from testimony; Hacking (1975) suggests that the scientific concerns with gauging such evidence reflects analogous concerns in legal and commercial spheres.

<sup>13</sup> It is not even clear that Gassendi would have needed to assume in this scenario a specifically atomist matter theory to get his theory of empirical knowledge off the ground.

generating independent support, particularly in empirical contexts, at a later stage.<sup>14</sup> In Gassendi's case, such independent support could have taken the form of justifying the theory of warrant by appealing not to atomism but to a robust yield of empirical results, or even the theological prominence of his epistemic principles, or their theological warrant. A justificatory strategy that points to empirical results may look better to us than the others from a modern perspective, and is consistent with Gassendi's overall empiricism;<sup>15</sup> however, Gassendi never develops any of these strategies. In any case, finding an alternative means for defending the theory of warrant (or his other epistemic principles) could not constitute a viable strategy, in light of Gassendi's view that the existing best explanation—his appeal to atomism—is at least contingently exclusive. He rules out alternative guarantees when he argues that the reliability of signs consists in the details of his optical and perceptual picture, which he has constructed specifically as an atomist model. If atomism turned out to be wrong—a possibility Gassendi allows—then an alternative defense of the epistemic principles might well be possible, too. Given the best explanation (and best evidence for such), though, the circle remains in place.

If these two approaches fail, and a circle cannot be avoided, one might yet hope that something of Gassendi's reasoning can be sal-

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<sup>14</sup> Harold I. Brown suggests that a significant obstacle to 'legalizing' circular argument through 'borrowing' strategies is a commitment to foundationalist theories of justification, which require full prior justification of any given claim before admitting it as a premise for any further claims; q.v. "Circular Justification", *PSA 1994* (1994) 1, 406–414). If this is right, then Gassendi faces one less obstacle to a less onerous circularity, given his strongly anti-foundationalist theory of justification.

<sup>15</sup> This option may be inviting if it seems odd for Gassendi as a seventeenth century thinker to rely on a physical hypothesis to support a theory of empirical knowledge. Yet it is a commonplace of early modern thought to appeal to physical accounts in defense of claims about the character of our knowledge. Even Descartes relies on a primary/secondary qualities distinction—as much a physical distinction as a metaphysical one, given its importance to his corpuscularian programme—to establish clarity and distinctness as the mark of our most secure sense-derived ideas. Against this historical background, what distinguishes Gassendi's account? First, he relies on the physical picture for his *entire* theory of knowledge given his claim that *all* knowledge (outside of theological knowledge) originates in sense-derived ideas (here he anticipates and likely influences Locke). Second, he suggests that it is just this physical picture which gives us good reason to accept, if only as verisimilitudinous, our sensory-based judgments about the world. Gassendi's theory of empirical knowledge accordingly may be considered novel and even controversial for his times, though not quite radical in this respect.

vaged. Consider the pragmatic tradition of interpreting circularity, not as simply consisting in relations among claims and their constituent premises (or, among arguments and their constituent claims), but as a function of such considerations as what the reasoner knows, believes, or means to imply by the reasoning deployed. As a consequence of this view, many arguments taken by themselves or in combination with others to be syntactically circular may turn out to be vindicated as modes of demonstration.<sup>16</sup> In short, a set of claims might not be demonstrated because of the formally circular nature of the reasoning underlying them, yet there might be pragmatic considerations whereby circularity does not obtain. This approach allows a certain charity to govern our interpretation of Gassendi's exposition of the arguments in question: he presents his reasoning for atomist claims in a different context from that reasoning he offers on behalf of his epistemic claims, and though he takes each argumentative instance as demonstrative, he does not give any indication that he intends the two lines of reasoning to interconnect in the formally circular way that they actually do. This is not to state the trivial point that he does not intend to reason circularly, but to suggest that his arguments are not intended to relate to one another altogether, rather to stand independently. One proposal along these lines might be that he does not directly draw our attention to the atomist premises of his epistemic theory (though they are not hidden premises, either) and so he could be said to lack the relevant intentions for relating the arguments because one 'side' of the circle is not fully emphasized in his own writings. This proposal is unconvincing, though, as emphasis is too murky a feature of argumentation upon which to rest such an interpretation.

More promising is the idea that Gassendi intends a different sort of implication relative to the two 'sides' of the circle than the one I have suggested so far. In particular, one must suppose Gassendi holds out the possibility of further developments in the respective chains of reasoning, taken as he was with the empirical revisability of all knowledge and the reasoning thereto. Thus, while the two lines of reasoning may contingently yield a circle, each line is revisable

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<sup>16</sup> Sorenson offers an overview of the distinction between syntactic and pragmatic views, and a rigorous defense of the latter; q.v. Roy Sorenson, "'P, therefore, P' without Circularity", *Journal of Philosophy* 88 (1991) 5, 245–266.

as are the relations among them; there is nothing inherent or fixed about them. While this view of things may not acquit Gassendi of the formal syntactic charge of circularity, it suggests pragmatic grounds upon which he might be seen to commit a contingent and therefore rectifiable sin of circular reasoning.<sup>17</sup>

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<sup>17</sup> Another approach altogether would be to take this putative circularity as an instance of something like Hempelian self-evidencing explanation: the atomist theory (H) accounts for the theory of warrant (E), though the theory of warrant permits or provides evidence for the atomist theory. Indeed, following Lipton's conception of IBE as an extension of self-evidencing explanation, one might construe the apparent circularity in this more friendly way: it is just because the atomist theory (H) explains how we have that theory of warrant (E) that the warrant theory (E) yields evidence for it (H).

Either of these construals falls apart, though, just in case the theories of warrant and atomism do not bear relations to each other of cause and effect or hypothesis and evidence (per Hempel and Lipton)—and it is apparently insufficient to establish such relations that, for example, the one yields or permits evidence for the other. Yet one can imagine a generalized view of the Hempel and Lipton models that aptly characterizes the sorts of relations these theories bear in Gassendi's thought. Such a generalization would extend those models to non-causal hypotheses or, as may seem characteristic of the case at hand, hypotheses of a physically causal character with consequences (not 'effects' *per se*) of a non-physical (in this case, epistemic) nature.

Even on this construal, though, questions remain as to whether (a) self-evidencing hypotheses are truly non-vicious and, if so, (b) IBE is a legitimate extension thereof. The resolution of these questions aside, it is clear that Gassendi holds that (i) his atomism accounts for the viability of his theory of warrant, that (ii) such evidence as provided by that theory of warrant supports the atomism theory (a generalized version of the Hempel model), and that it is precisely because of (i) that (ii) (a generalized version of the Lipton model). That is, according to this reading of Gassendi, were it not the case that atomism—specifically, the atomist accounts of perception and sensory physiology—upheld the theory of warrant by vouching for the reliability of sensory data, then such sensory data as we might hope to attain as evidence for an atomist hypothesis would not count in its favor.

One may object that such a reading is unsatisfactory—as is typically said of IBE reasoning—because of the possibility of alternate hypotheses: some other account of perception or sensory physiology might have allowed the right sorts of data to sustain an atomist theory. Gassendi, for his part, does not entertain that possibility. Nevertheless, while he does not consider the entire universe of such accounts, he contrasts the atomist views with rival views. What makes his reasoning compelling from an IBE perspective, then, is that given the contrasts he provides (and the going physical and chemical physiology of the day), the best account as to how his theory of warrant may yield the reliability of sensory data is offered by an underlying atomist theory of perception.

In highlighting the close relations between these two principal elements of his philosophy, we can see that, even if Gassendi's reasoning for each element did not constitute a circle, or the circle was not vicious, or somehow fixable despite being vicious, a familiar problem lurks here once again: unrealized empiricist aspirations. His strong empiricism presents expectations that cannot be satisfied by his many appeals to *a priori* argument and few pertinent observational and experimental reports on behalf of atomism. Gassendi defends his theory of epistemic warrant by appealing to an atomist matter theory. While the defense of that matter theory is tendered as partly empirical, much of his atomist picture is laid out in fanciful detail—a vividly imagined expansion and 'improvement' on the Epicurean theory. This includes the creative proposals that objects are pulled towards the Earth as a result of being attached to rays of special 'gravity' atoms,<sup>18</sup> and that perceptual data directly communicating properties of the percepts are transmitted via corpuscular packets. Given that the very reliability—hence justification—of empirical belief depends on atomist theories of perception, Gassendi's failure to adequately defend atomism on empirical grounds in turn undermines his physicalist reasoning for those basic elements of his theory of knowledge. Circularity aside, then, he risks his core empiricist claim on a physiological account that cannot satisfy his own methodological criteria.

One way to think about these problems is to consider that, by the physical and physiological constraints imposed upon us, the empirical evidence required by a matter theory such as atomism represents must be indirect—even in our own age of sophisticated microscopy. Such evidence is only admissible by empiricist standards given a theory of knowledge that, like Gassendi's, allows inference of claims about the nonevident from claims about the evident on roughly the same, if not identical, grounds for allowing inferences to claims strictly about the evident.<sup>19</sup> In particular, whatever account warrants admitting such indirect evidence should allow that, at a

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<sup>18</sup> *O I* 345b–346b; q.v. chapter twelve.

<sup>19</sup> The standards for warranting inferences to claims about the evident and the nonevident need not be identical but they have to be fairly similar for the empiricist or else the standard will deviate too far from whatever counts as knowledge from the senses. The non-empiricist naturally does not face this sort of constraint.

minimum, the method that takes us from the evident to the nonevident guarantees some empirical means of confirming claims about each, and that whatever principles by which we justify a given empirical judgment are indifferent to the perceivability of objects of such judgments. In short, the means of arriving at both sorts of claims must be empirical, and the means of justifying empirical claims must be (at least roughly or partly) the same for both sorts of claims. Indeed, Gassendi's account is consistent with this form: reasoning by analogy and ampliative inference allow us to draw on available sensory data to make judgments about hidden mechanisms or qualities—and such reasoning is guaranteed, by the availability of the data only given the existence of what is hidden. Further, trustworthy and relevant sensory information lend probabilistic warrant to empirical judgments, whether or not those judgments concern bodies that are directly perceivable. Had he a very different notion of making judgments about the subperceivable and deriving the warrant for them, he should have had great difficulty fitting his empiricist scruples to his interest in promoting an atomist matter theory.<sup>20</sup> In short, such scruples and the promotion of any such corpuscularianism demand something at least similar to his theory of warrant and allied epistemic principles.

Going the other way is a bit tougher: it is not a prerequisite of robust empiricism that one upholds atomism. As a thoroughgoing empiricist, however, Gassendi wants to secure a trustworthy characterization of sensory information by telling a physical and physiological story about the interaction of the senses with the material world. He might have pleaded ignorance here but the contemporary work of iatrochemists, other chemical experimenters, and microscopists—and his commitment to an Epicurean programme—suggest to him that the world is composed of small particles. So an appeal to some sort of corpuscularian hypothesis is not unreasonable, and perhaps expectable, despite the apparent circularity that emerges when putting these arguments together.<sup>21</sup> While there is nothing inevitable about these arguments, then, Gassendi's atomist reasoning

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<sup>20</sup> Thus, for example, had he dismissed signs as insufficient to providing empirical evidence of the subperceivable, he would have cut off any possibility of empirical data that suggests an atomic structure of matter.

<sup>21</sup> As I have noted, the circle does not seem to have been apparent to Gassendi himself.



proceeds along common (if mistaken) early modern paces. In this sense, his predicament is peculiarly a product of his times. A more sophisticated theory of perception, for example, might support a reliabilist theory of knowledge without appealing to this or any other particular underlying matter theory. Yet Gassendi's problems in this context also foreshadow difficulties faced by later thinkers: defending empiricist method on empirically derived grounds likely requires avoiding a reliance on the same method one seeks to justify—which in turn suggests a non-foundationalist theory of justification. As it happens, there are most, if not all, the elements of such a theory of justification in Gassendi's reliabilism, though he never quite brings this forth as a solution—much less acknowledging the difficulty it might resolve.



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